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# Development of a Geophysical Data Fusion System for Assessment and Remediation Studies of Polluted Groundwater Aquifers

J. R. Murphy
D. C. O'Neill
B. W. Barker

Maxwell Laboratories, Incorporated
S-CUBED Division
P. O. Box 1620
La Jolla, CA 92038-1620

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This technical report has been reviewed and is approved for publication.

JAMES F. LEWKOWICZ
Contract Manager
Earth Sciences Division

JAMES F. LEWKOWICZ, Director
Earth Sciences Division

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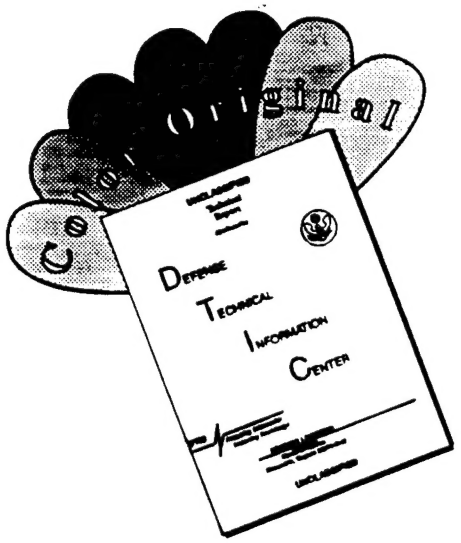


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J. R. Murphy
D. C. O'Neill
B. W. Barker

**7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)**
Maxwell Laboratories, Inc.
S-CUBED Division
PO Box 1620
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The research described in this report is directed toward the development of a workstation-based data management, analysis and visualization system which can be used to improve the Air Force's capability to evaluate site specific environmental hazards. The initial prototype system described in this report is directed toward a specific application to the Massachusetts Military Reservation (formerly Otis Air Force Base) on Cape Cod, Massachusetts. This system integrates a comprehensive, on-line environmental database for the site together with a map-based graphical user interface which facilitates analyst access to the databases and analysis tools needed to characterize the subsurface geologic and hydrologic environments at the site.

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# I. INTRODUCTION

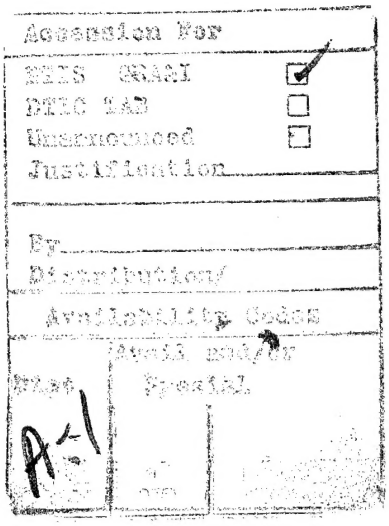
The Air Force has recently adopted a goal to insure that all of their facilities shall be environmentally clean by the year 2005. A significant element of the program which is being designed to achieve this goal is the development of new geophysical technology for characterizing hazardous waste sites, with particular emphasis on the assessment and remediation of any polluted groundwater aquifers which may exist at the wide variety of Air Force facilities which are distributed throughout the U.S. This is a significant challenge in that these sites represent a great diversity of geological and hydrological environments and, consequently, their effective characterization is likely to involve many different types of information and geophysical survey data. Thus, an ability to efficiently integrate or fuse all of these disparate data and analysis results will be an important component of any successful environmental assessment program.

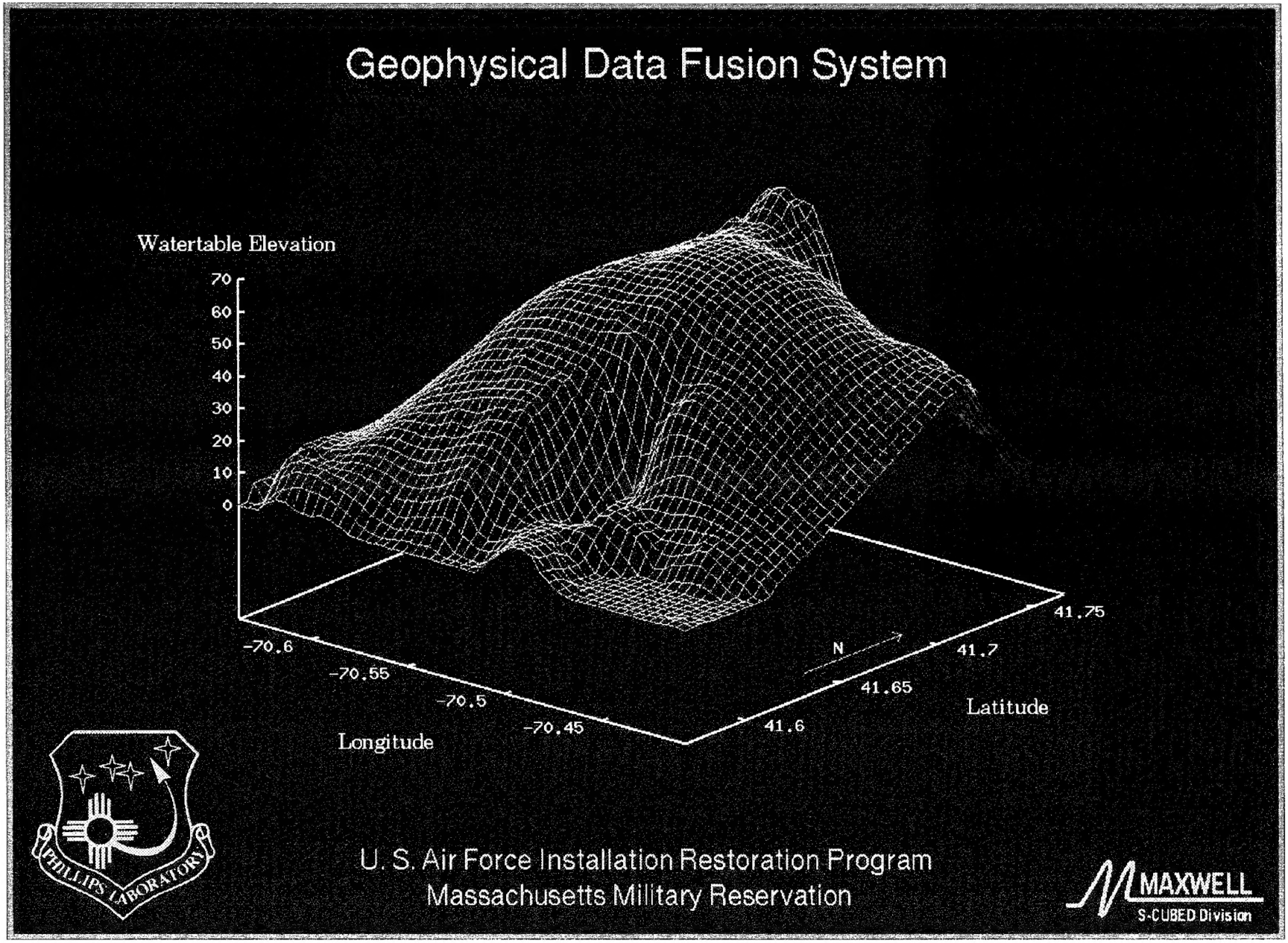
The research described in this report has the objective of improving the Air Force's capability to evaluate site specific environmental hazards through the development of an innovative, workstation-based data management, analysis and visualization system which will permit an analyst to easily apply a wide variety of site information and geophysical analysis tools to the assessment of specific sites. The ultimate goal is to develop a system which will integrate a comprehensive, on-line environmental database for a selected site together with a map-based graphical user interface which facilitates analyst access to the databases and analysis tools, an analysis module containing state-of-the-art hydrological and geophysical theoretical simulation models and a visualization system for the display and evaluation of data and model simulation results within a single, homogeneous analysis environment.

The initial prototype system described in this report is directed toward a specific application to the Massachusetts Military Reservation (formerly

Otis Air Force Base) located on Cape Cod, Massachusetts. This site was chosen because environmental restoration studies have been on-going at this location for more than 10 years and, consequently, a wide variety of geotechnical data are already available for demonstration of system capabilities. Moreover, its proximity to the Phillips Laboratory Geophysics Directorate at Hanscom Air Force Base in Massachusetts facilitates interaction with base personnel and acquisition of supplemental data.

Some of the capabilities and functionality of the prototype Geophysical Data Fusion System (GDFS) are graphically illustrated in the following pages where displays of the workstation screens encountered by an analyst in a typical processing session are presented.




Geophysical Data Fusion System
Watertable Elevation
70
60
50
40
30
20
10
0
-70.6
-70.55
-70.5
-70.45
Longitude
41.6
41.65
41.7
41.75
Latitude
N
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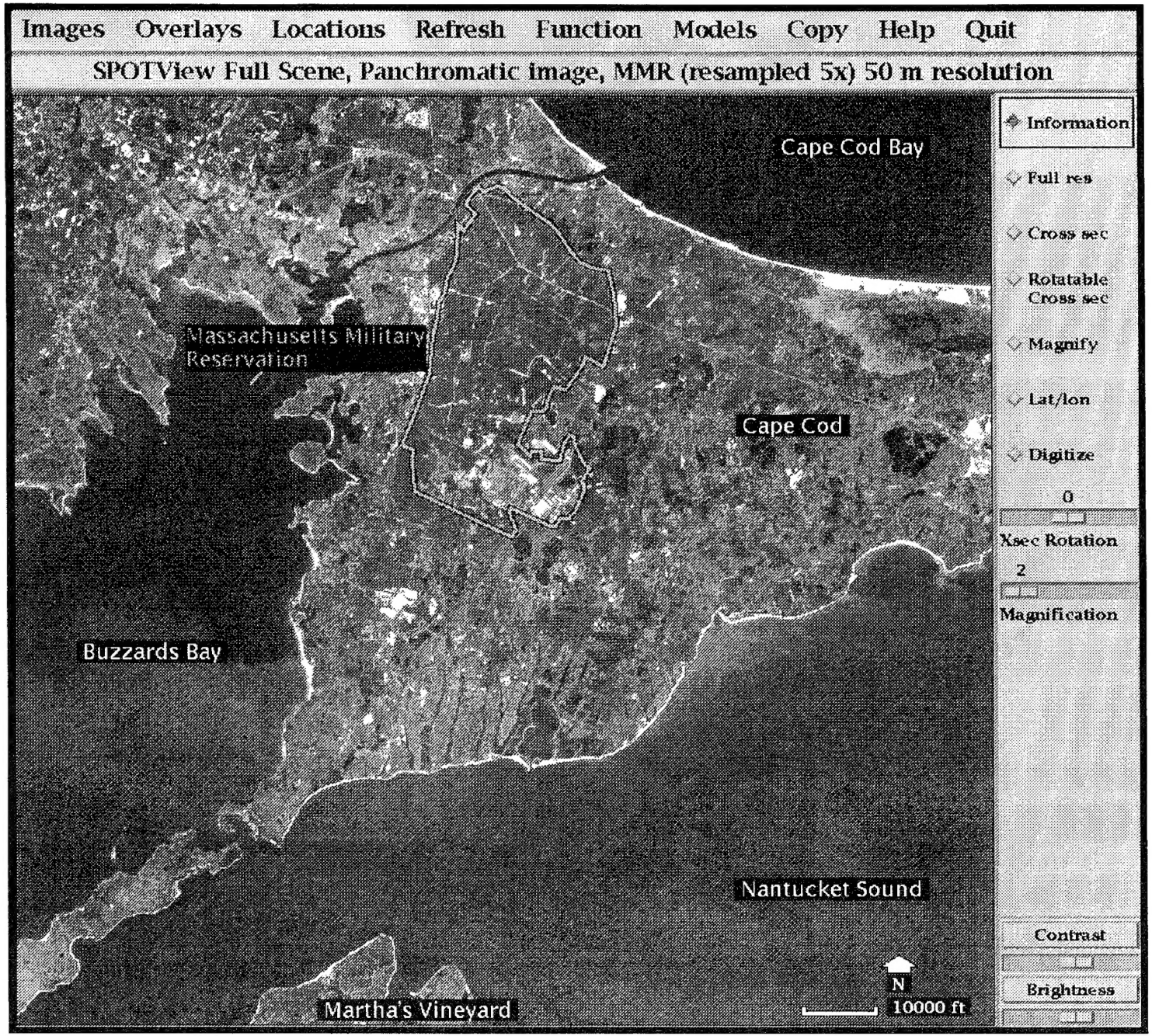
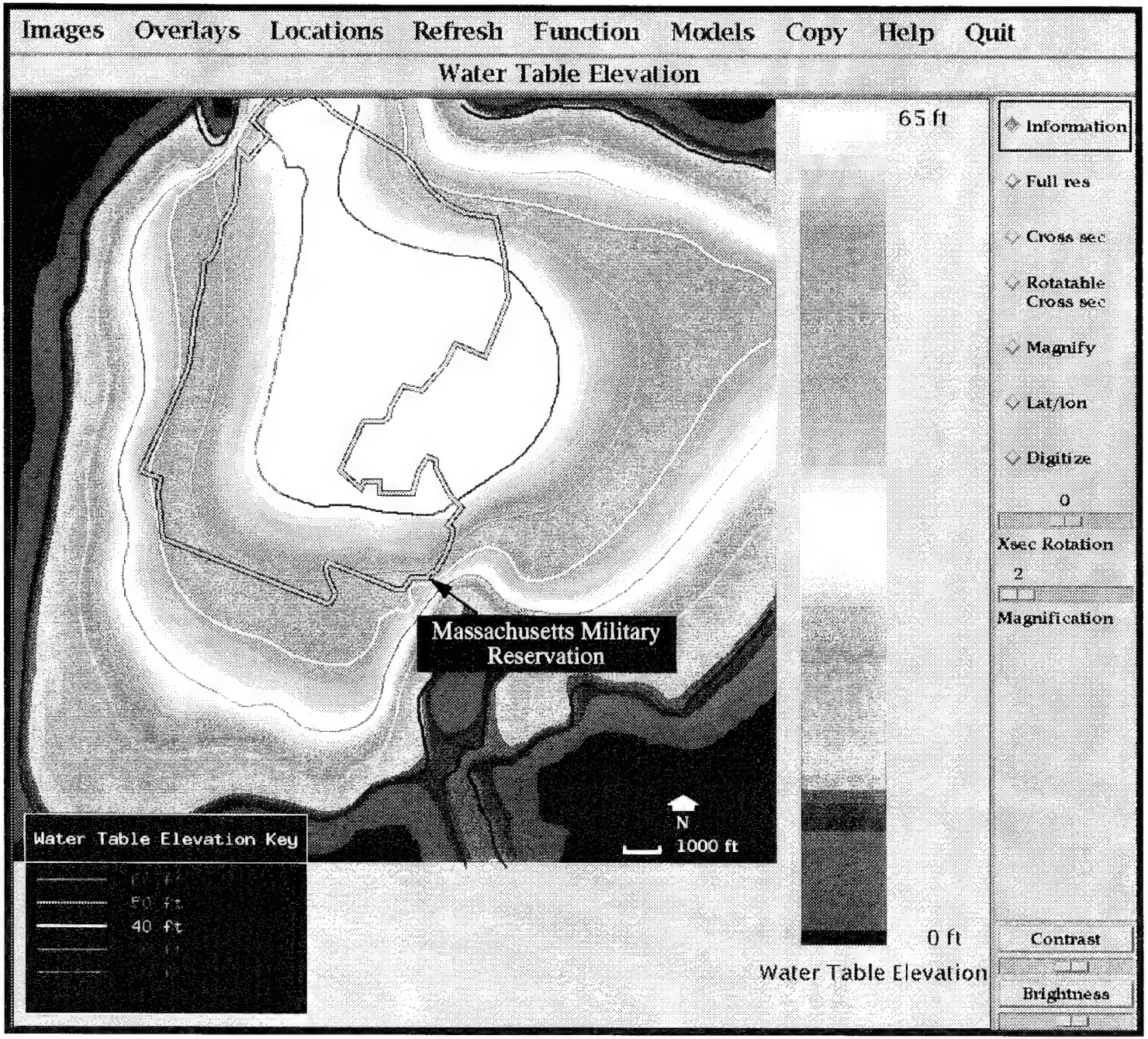


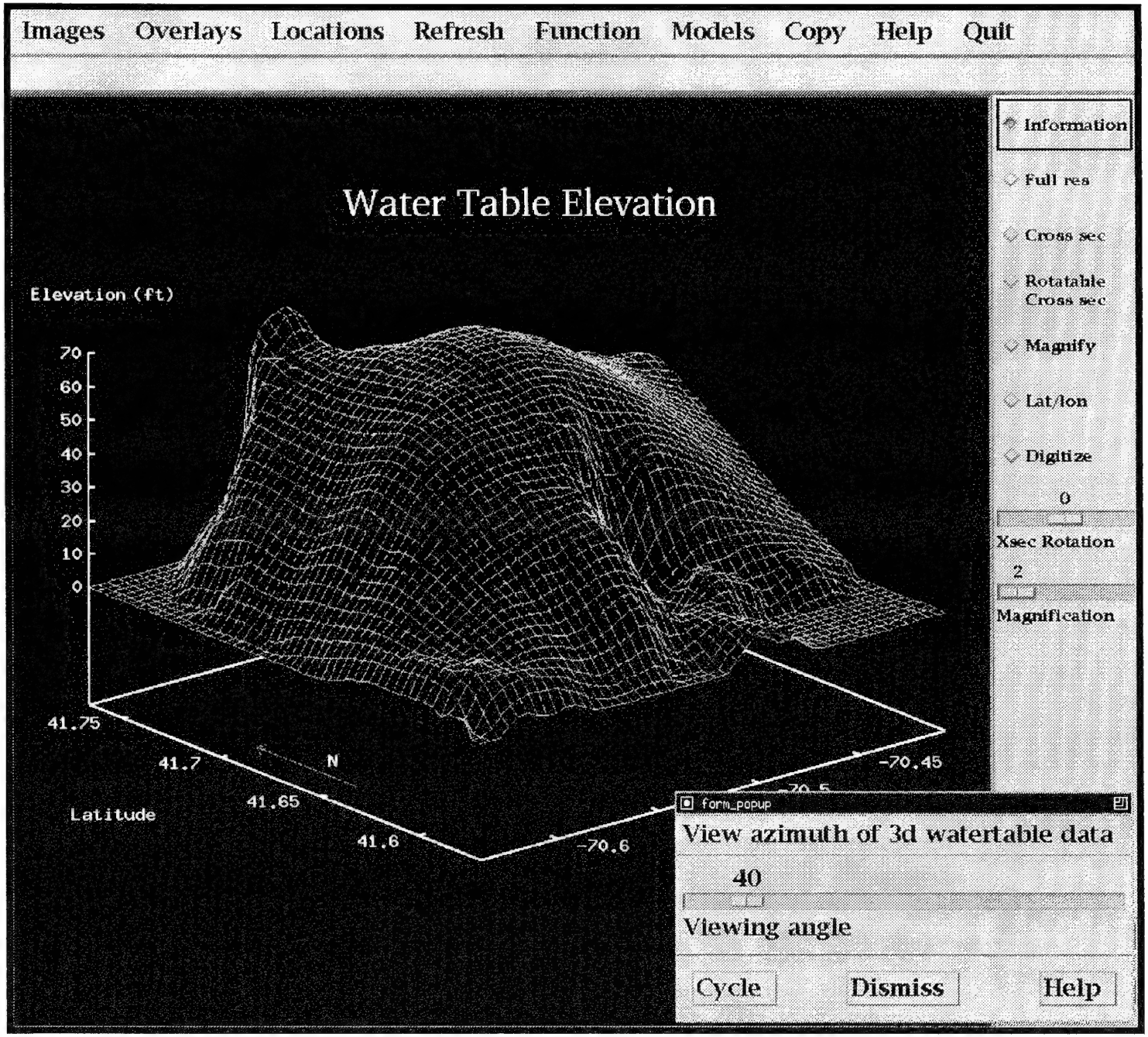

Compressed SPOT satellite image of western Cape Cod ( 50m resolution ) with superimposed boundary of the Massachusetts Military Reservation ( MMR ).


Compressed SPOT satellite image of western Cape Cod ( 50m resolution ) with superimposed surface geologic map and MMR boundary.

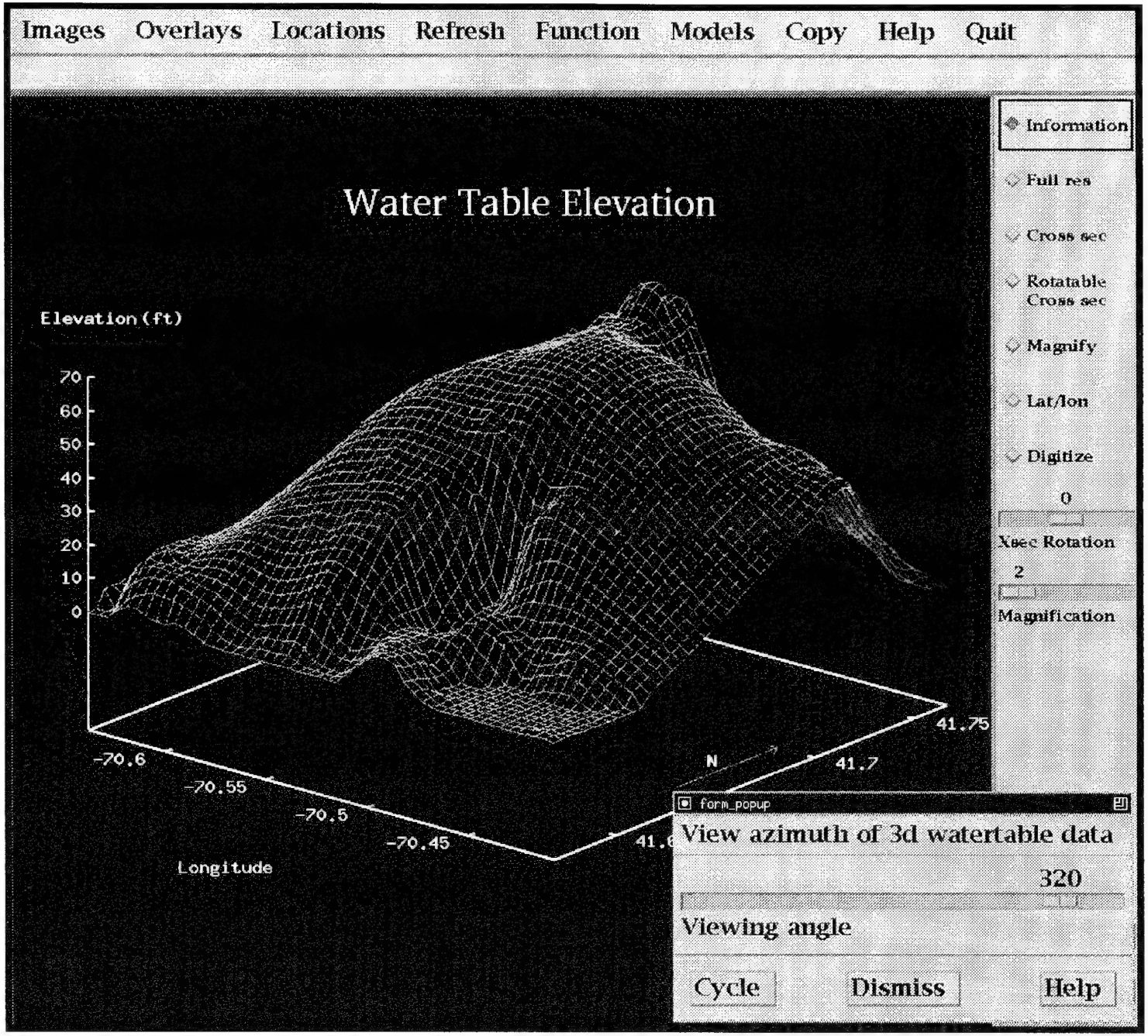

Color-coded representation of Defense Mapping Agency (DMA) topographic data for western Cape Cod with superimposed surface geologic map and MMR boundary.



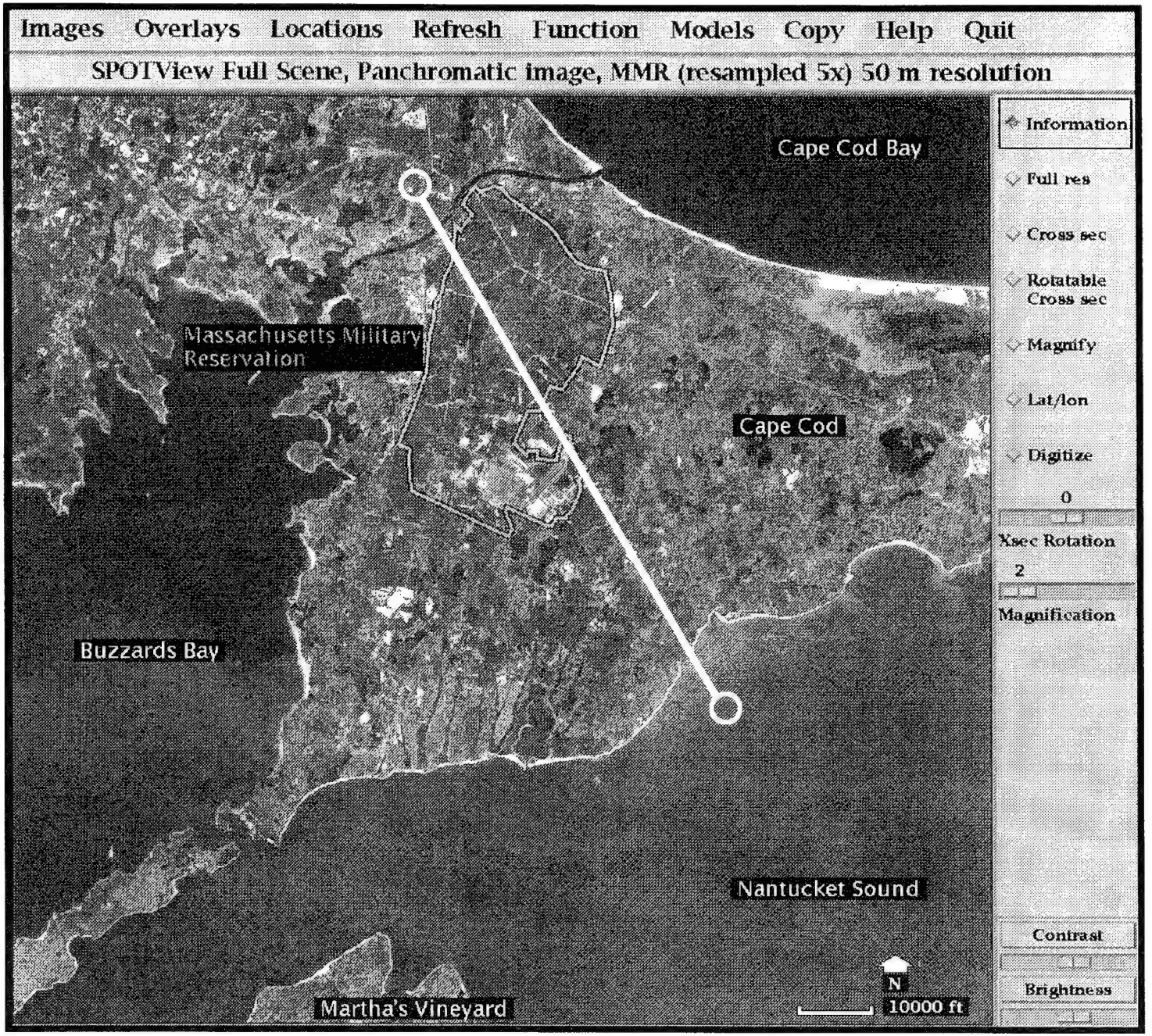

Color-coded representation of depth to water table for western Cape Cod with superimposed MMR boundary.



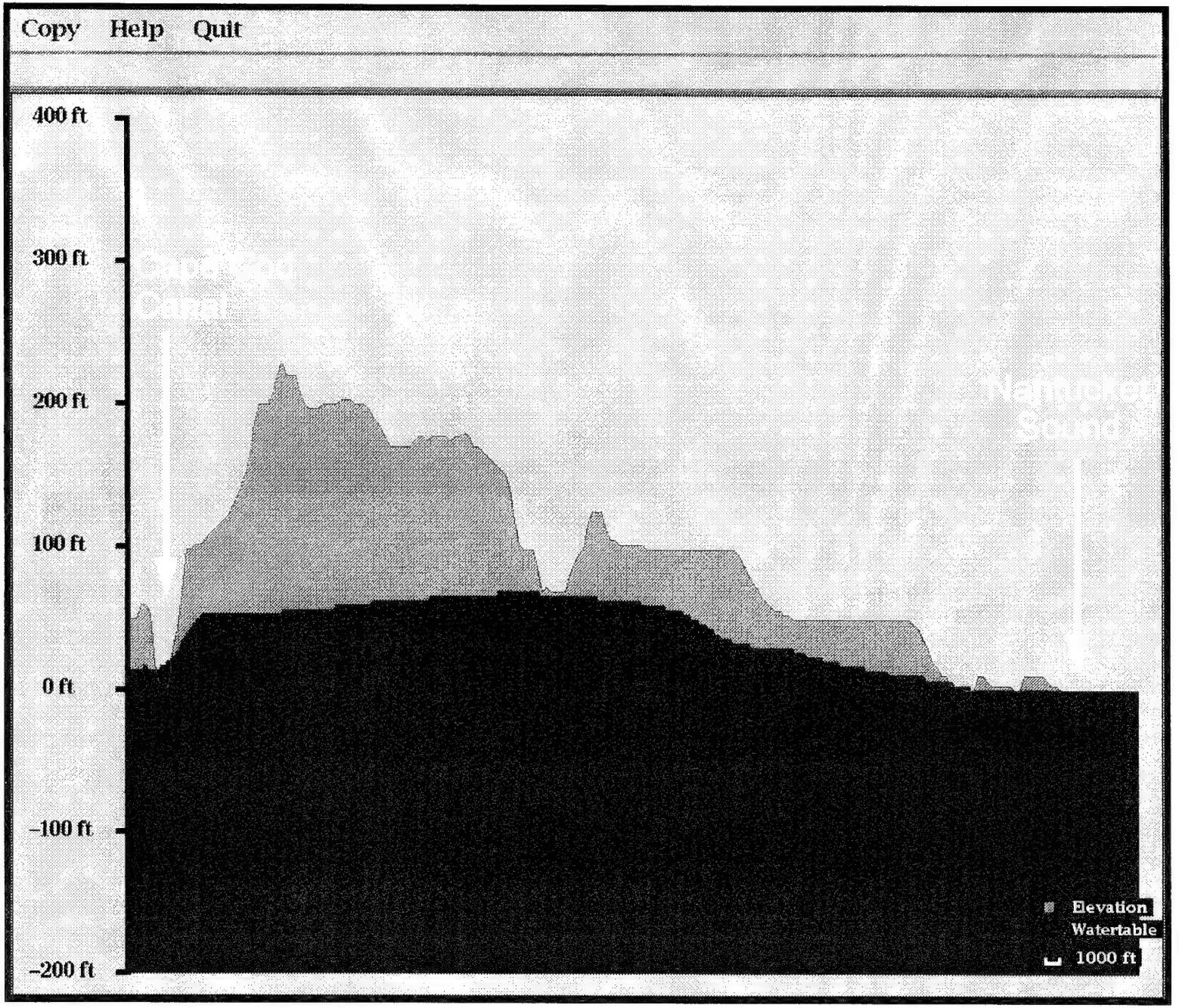

Three-dimensional wireframe representation of depth to water table for western Cape Cod; view looking northeast from an elevated point southwest of MMR.



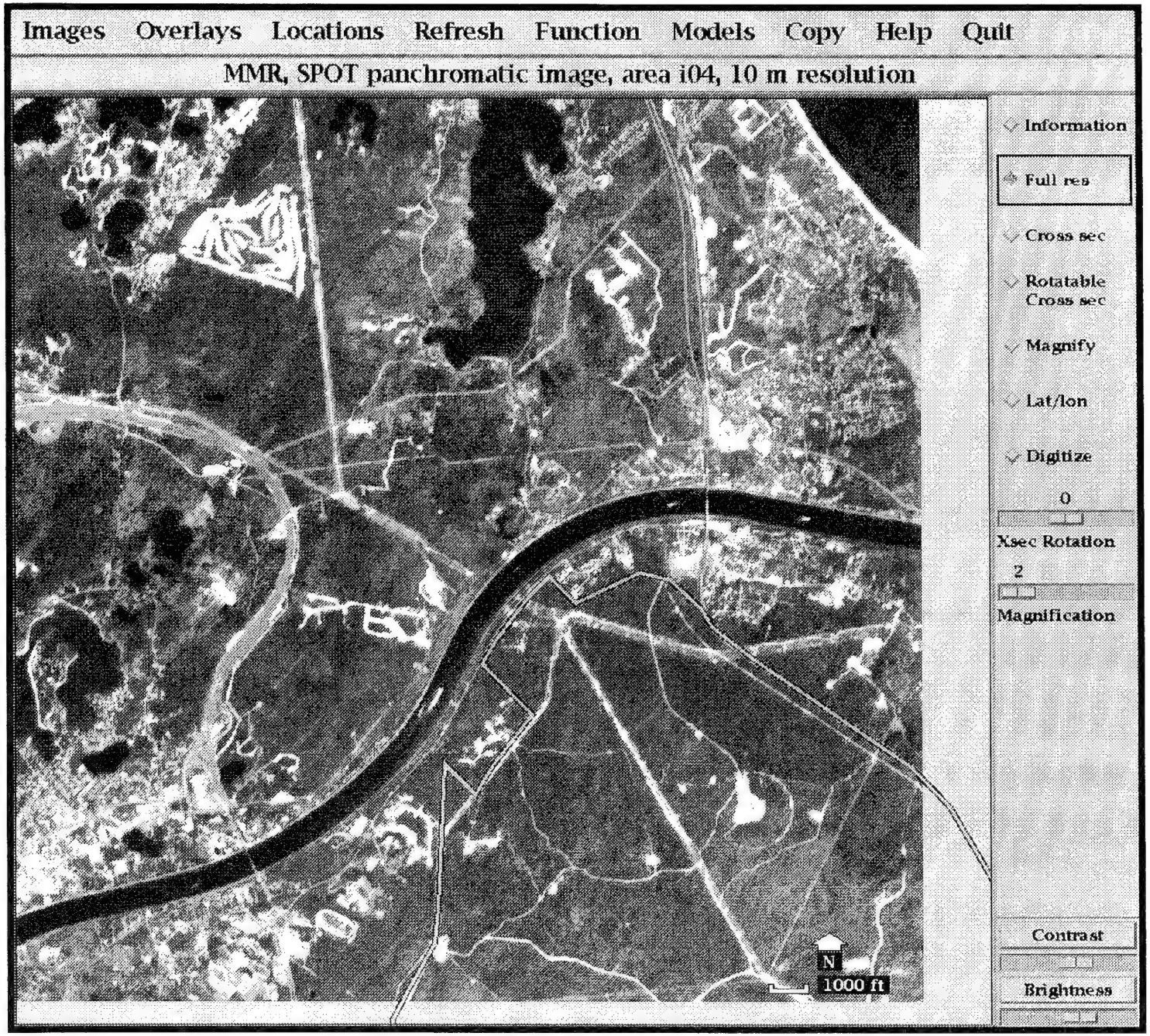

Three-dimensional wireframe representation of depth to water table for western Cape Cod; view looking northwest from an elevated point southeast of MMR.



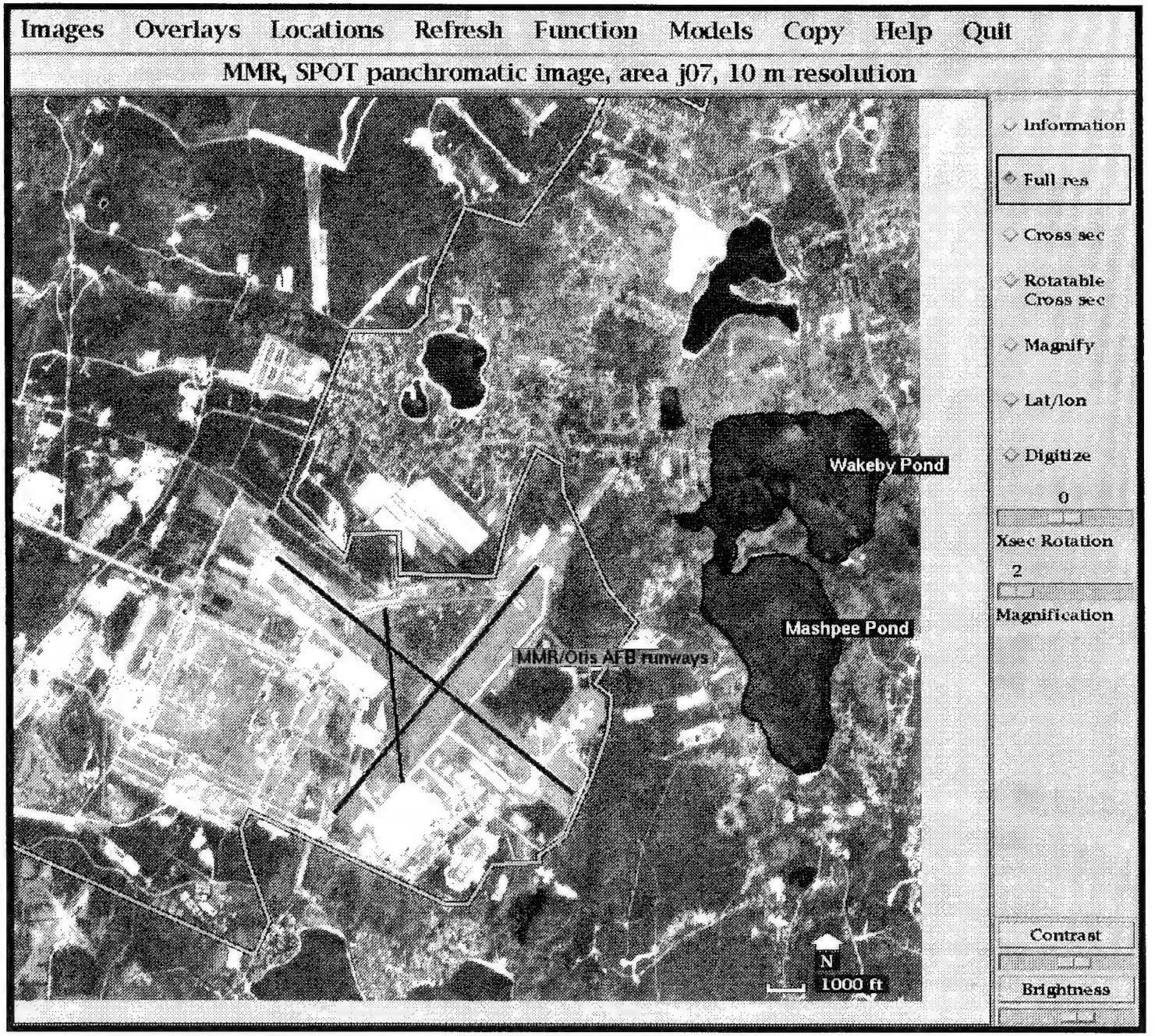

Interactively selected line running southeast across the Cape Cod Canal and MMR to Nantucket Sound.




Vertical subsurface section along the interactively selected line from the previous figure showing the variations in surface topography and depth to water table (orange/blue boundary) along that line.

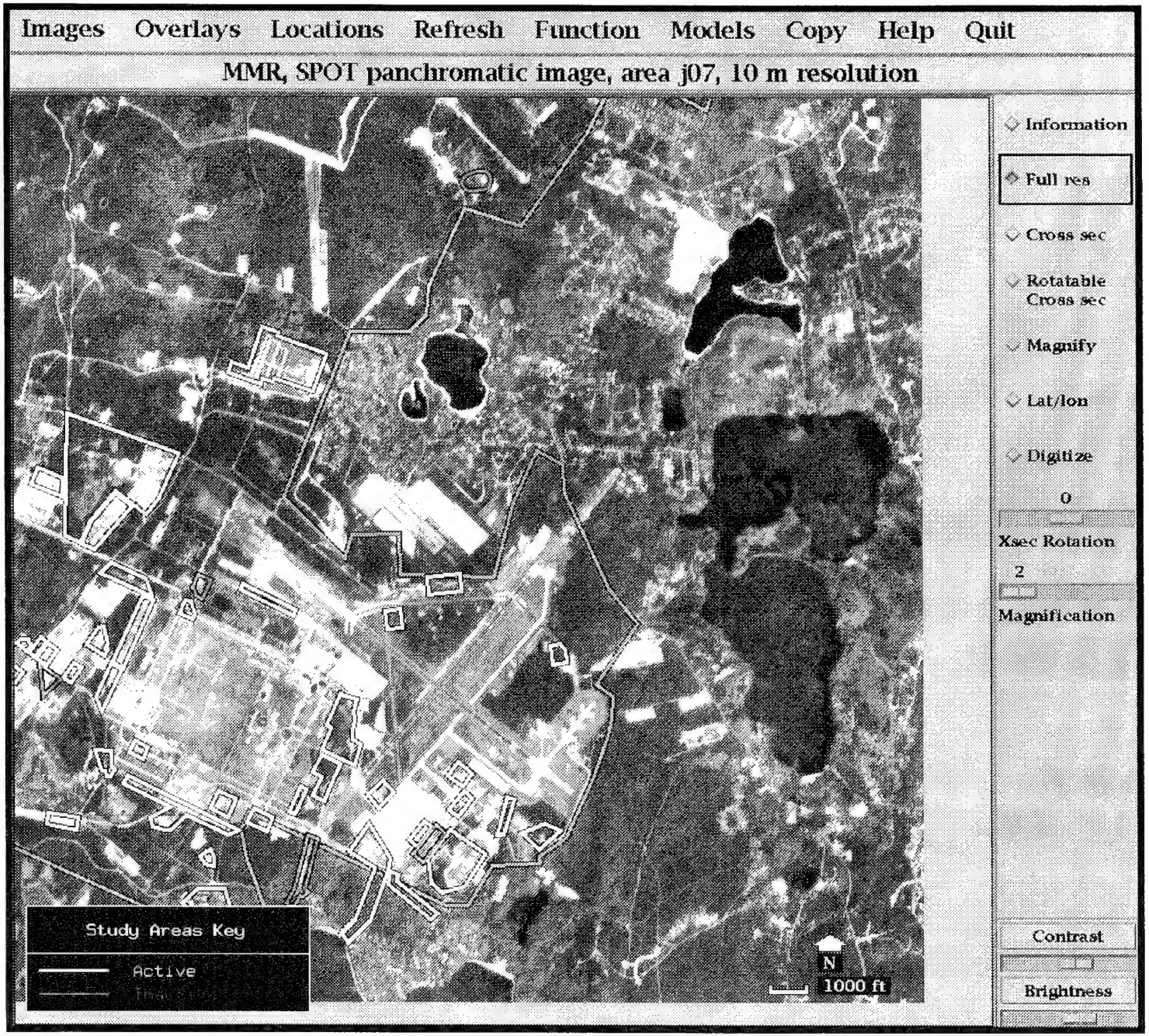



Full resolution (10m) SPOT image of central portion of Cape Cod Canal with superimposed northwestern boundary of MMR. Note that the canal bridges and ships in the canal are readily identifiable at this scale.

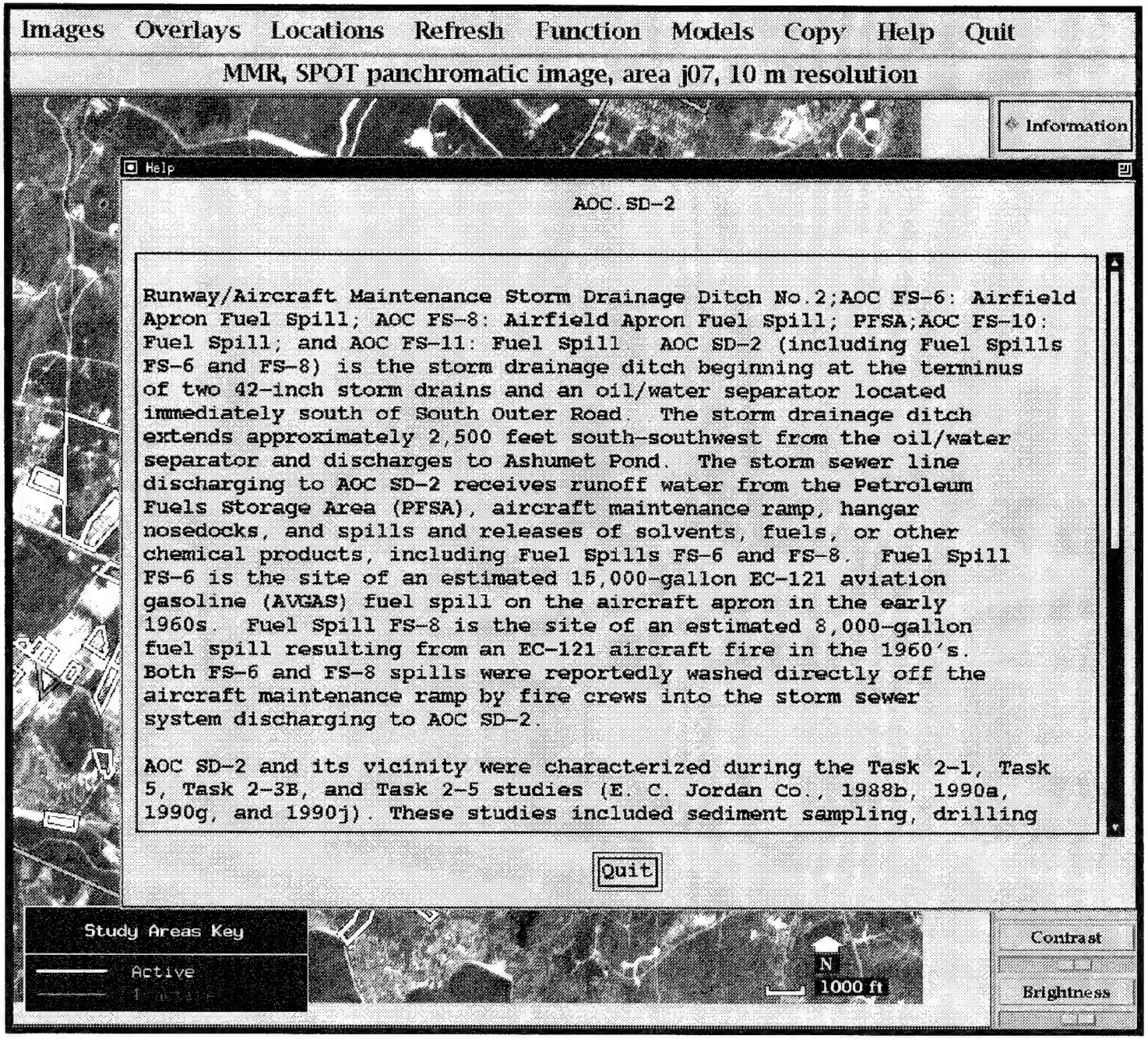



Full resolution (10m) SPOT image of southeast corner of MMR which encompasses most of the base facilities. The locations of the MMR boundary and several natural and man-made features in the area have been superimposed to orient the viewer.

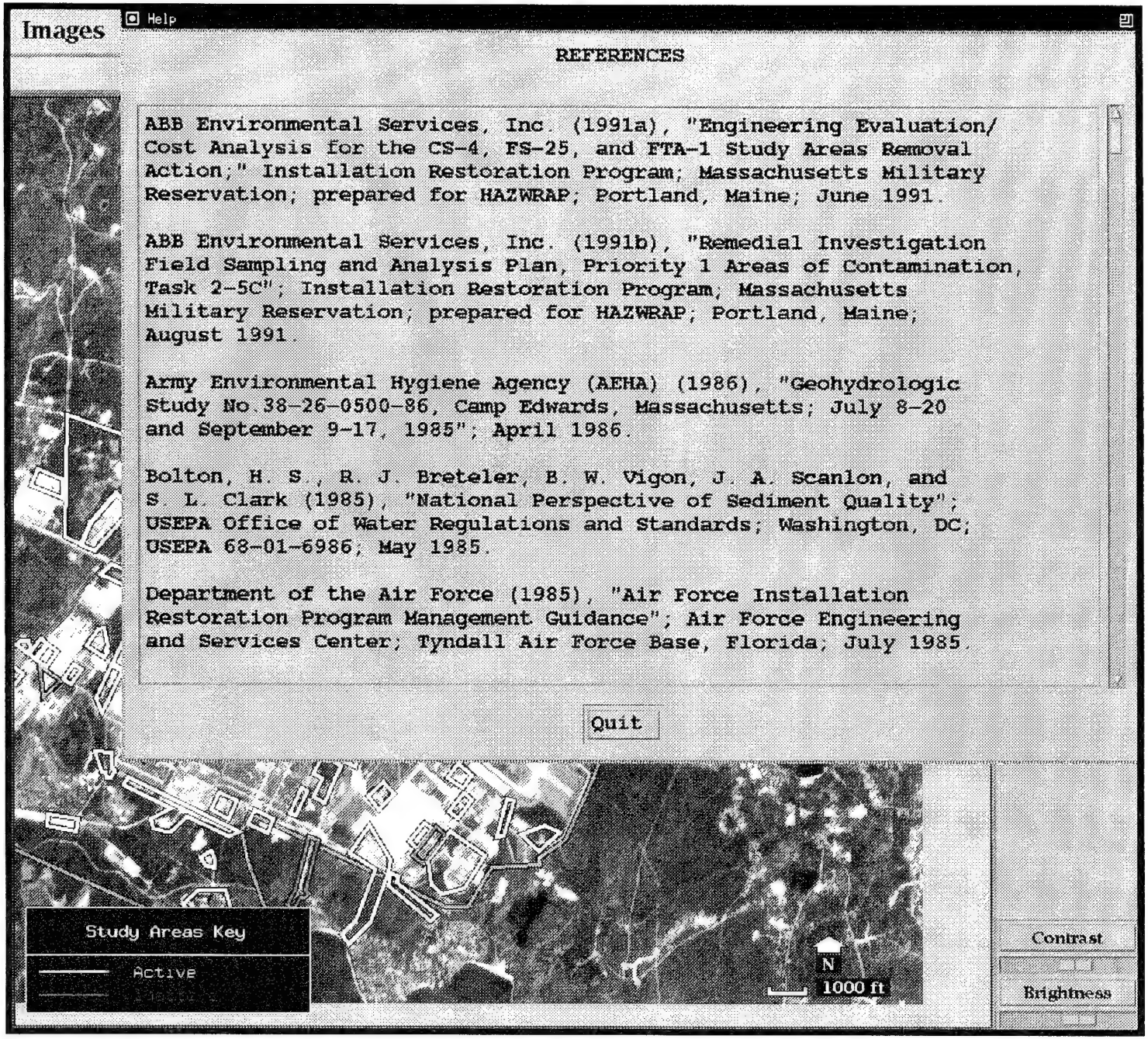

Full resolution SPOT image of the southeast corner of MMR illustrating the capabilities for the system user to interactively modify the contrast and brightness of the image and to magnify selected portions of the image.



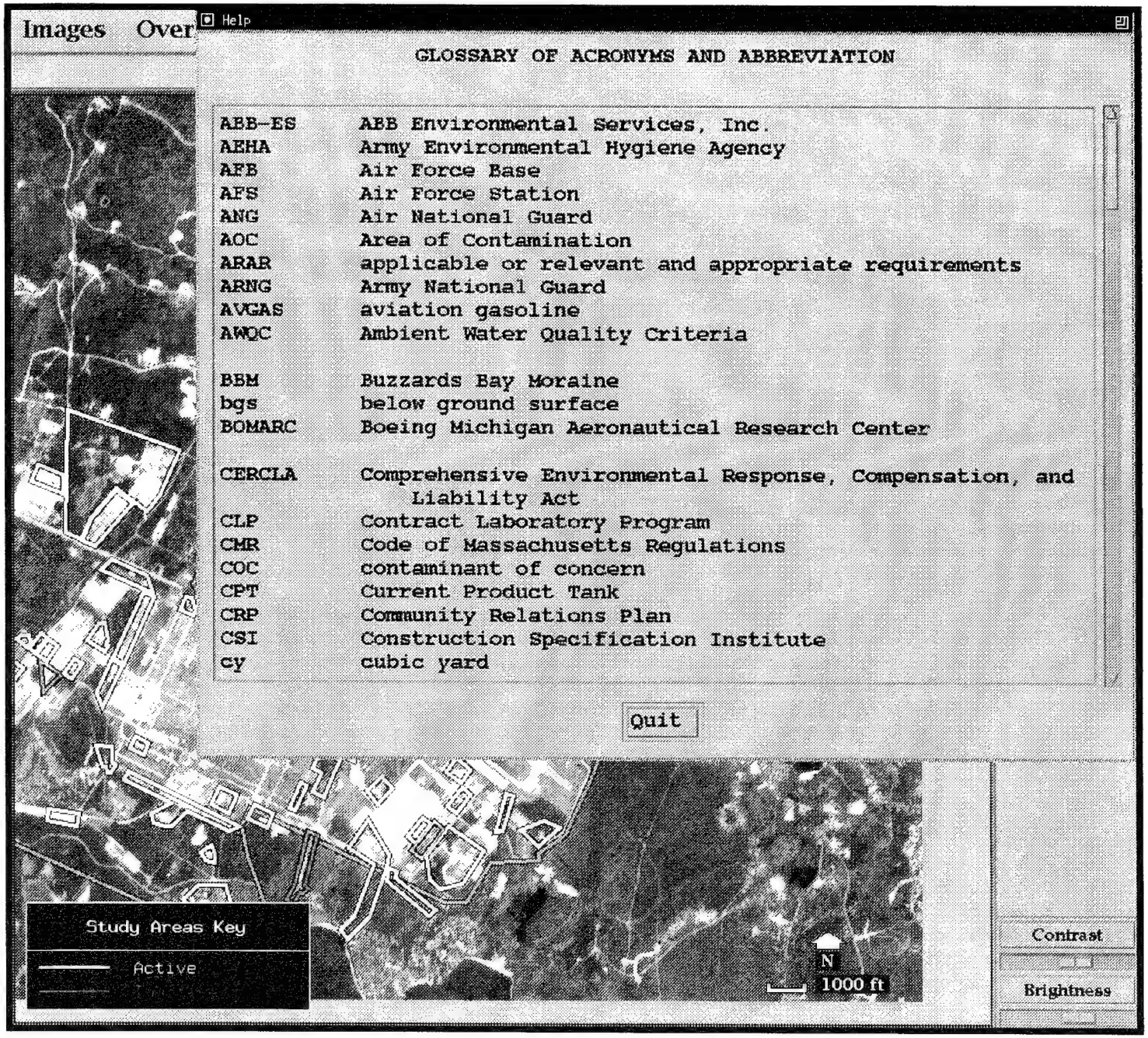

Full resolution SPOT image of the southeast corner of MMR with superimposed MMR boundary and outlines of areas being studied as possible sources of contamination.



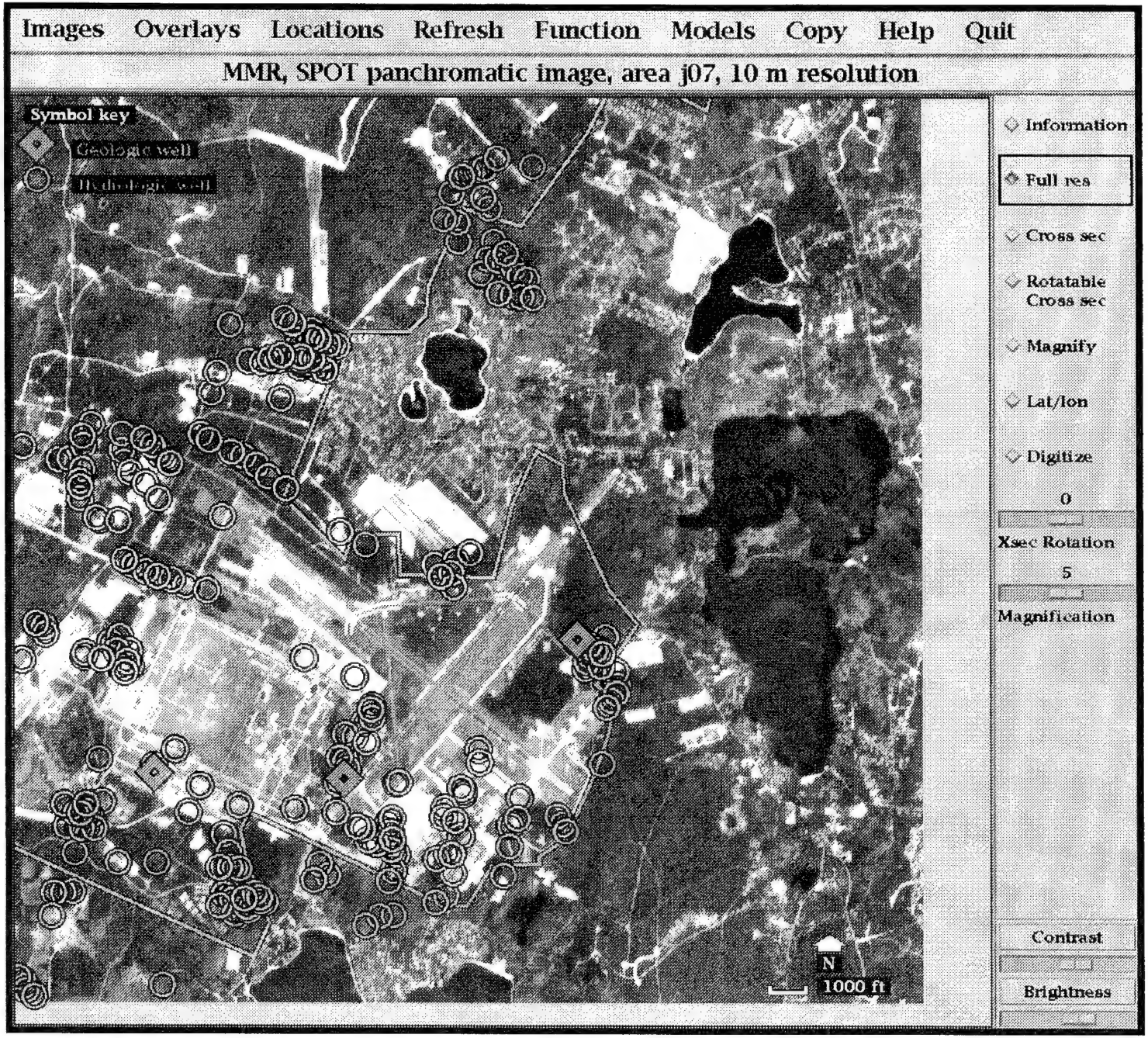

Example of online information documenting investigations of Study Area SD-2, which was automatically extracted from the database and displayed by clicking within the displayed SD-2 area outline with the mouse.



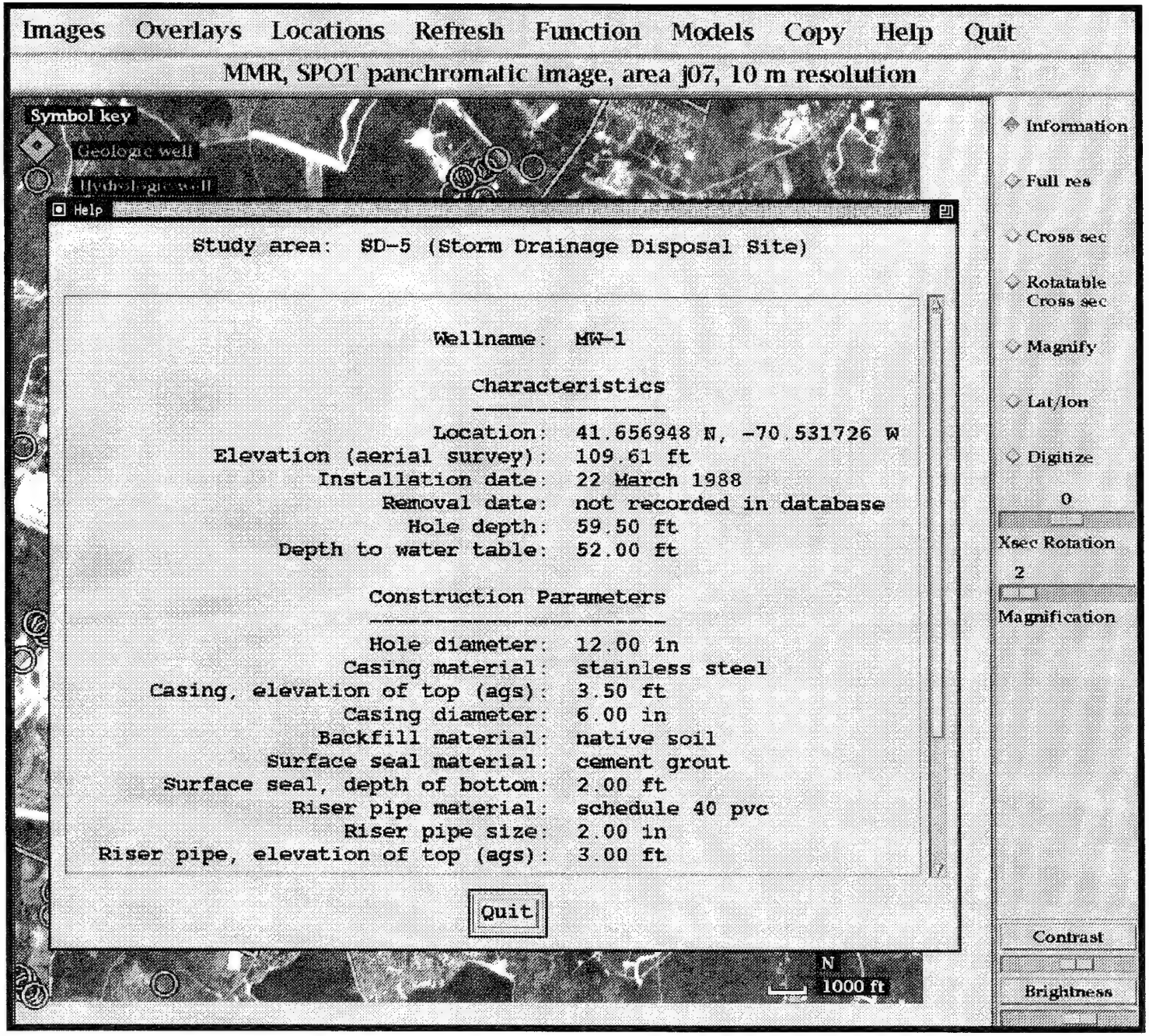

Sample of online file of MMR report references which can be accessed from the system HELP menu.



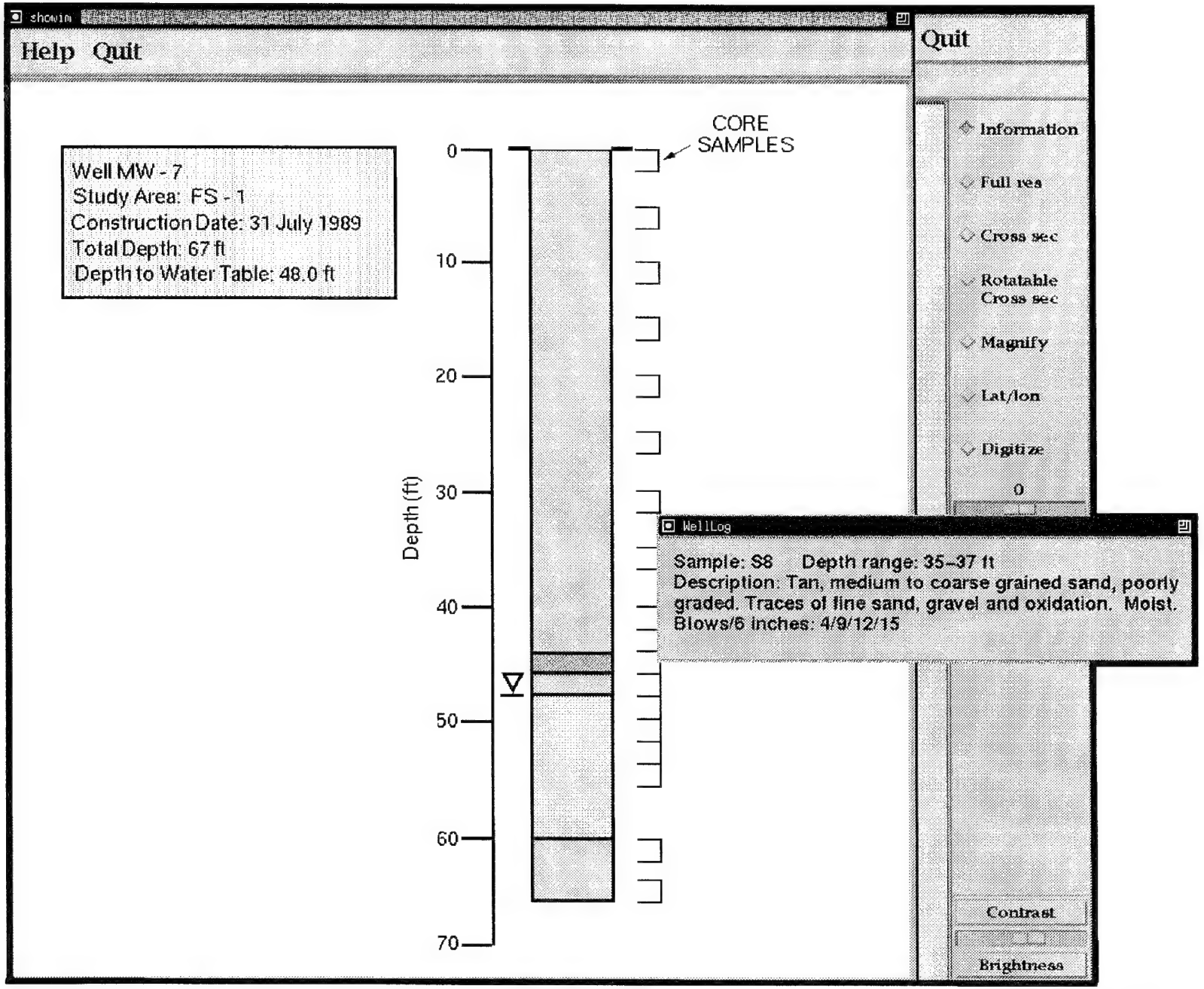

Sample of online file of MMR acronyms and abbreviations which can be accessed from the system HELP menu.



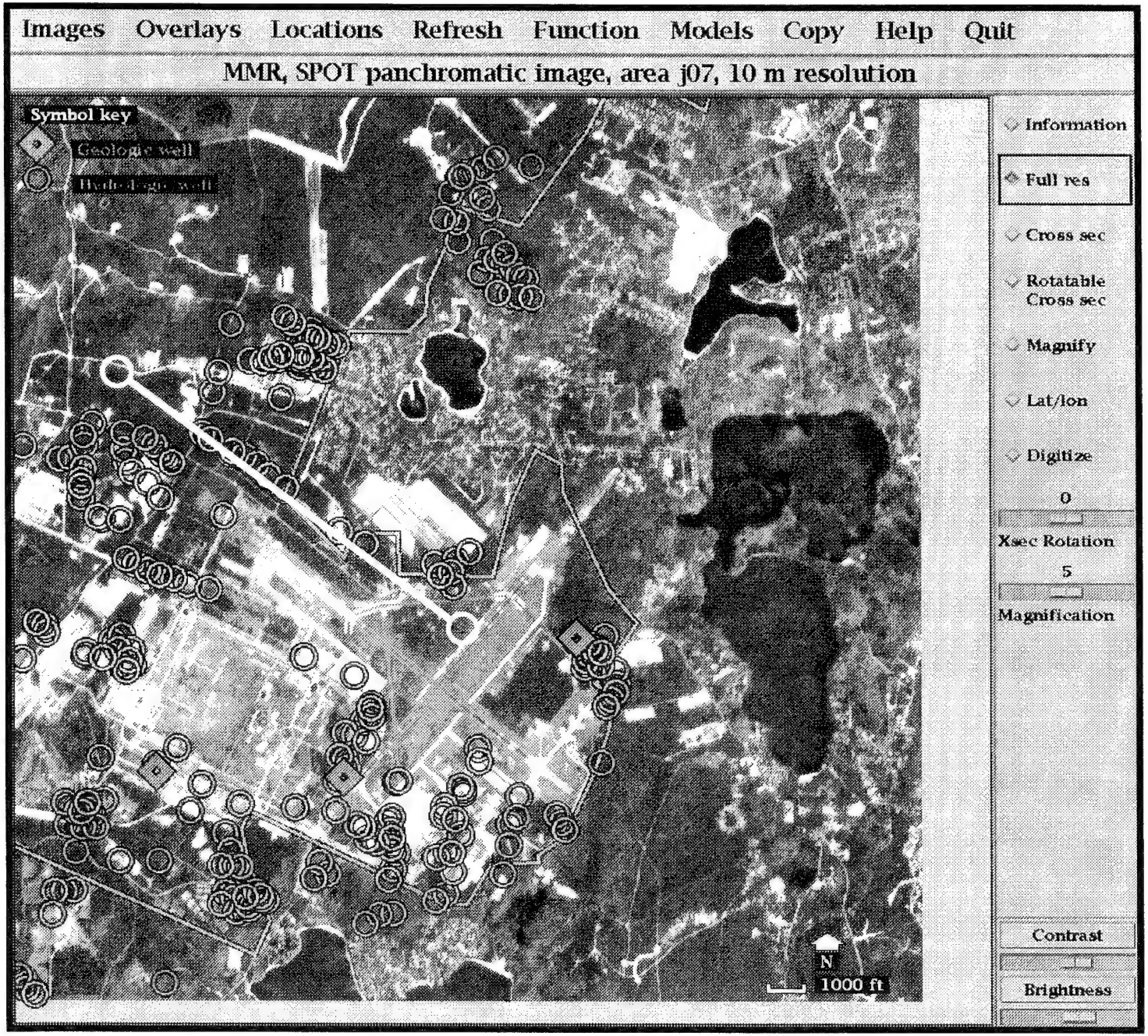

Full resolution SPOT image of the southeast corner of MMR with superimposed MMR boundary and locations of exploratory hydrologic and geologic wells in the area.



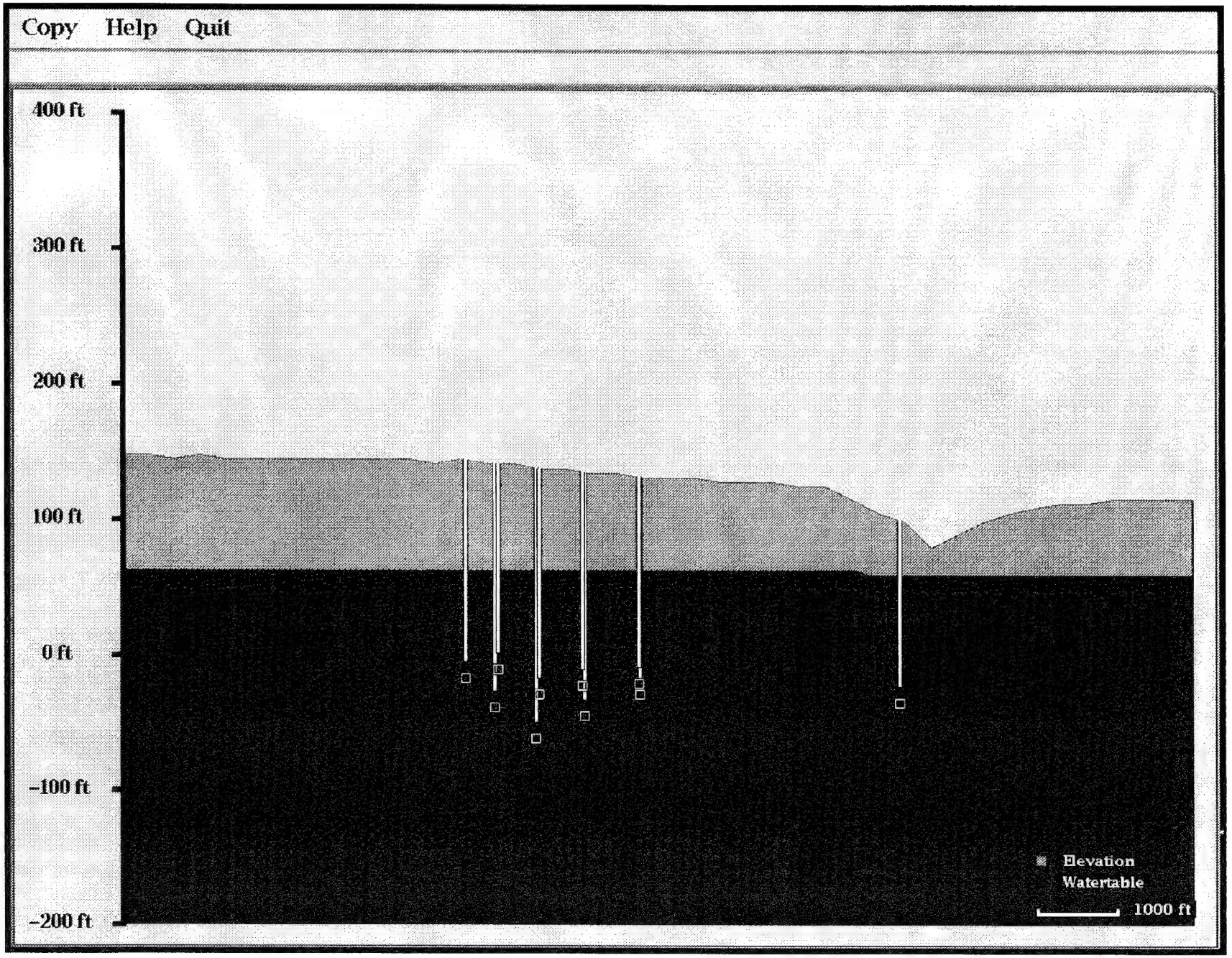

Sample of online hydrologic well information which can be accessed by clicking on the well location with the mouse.



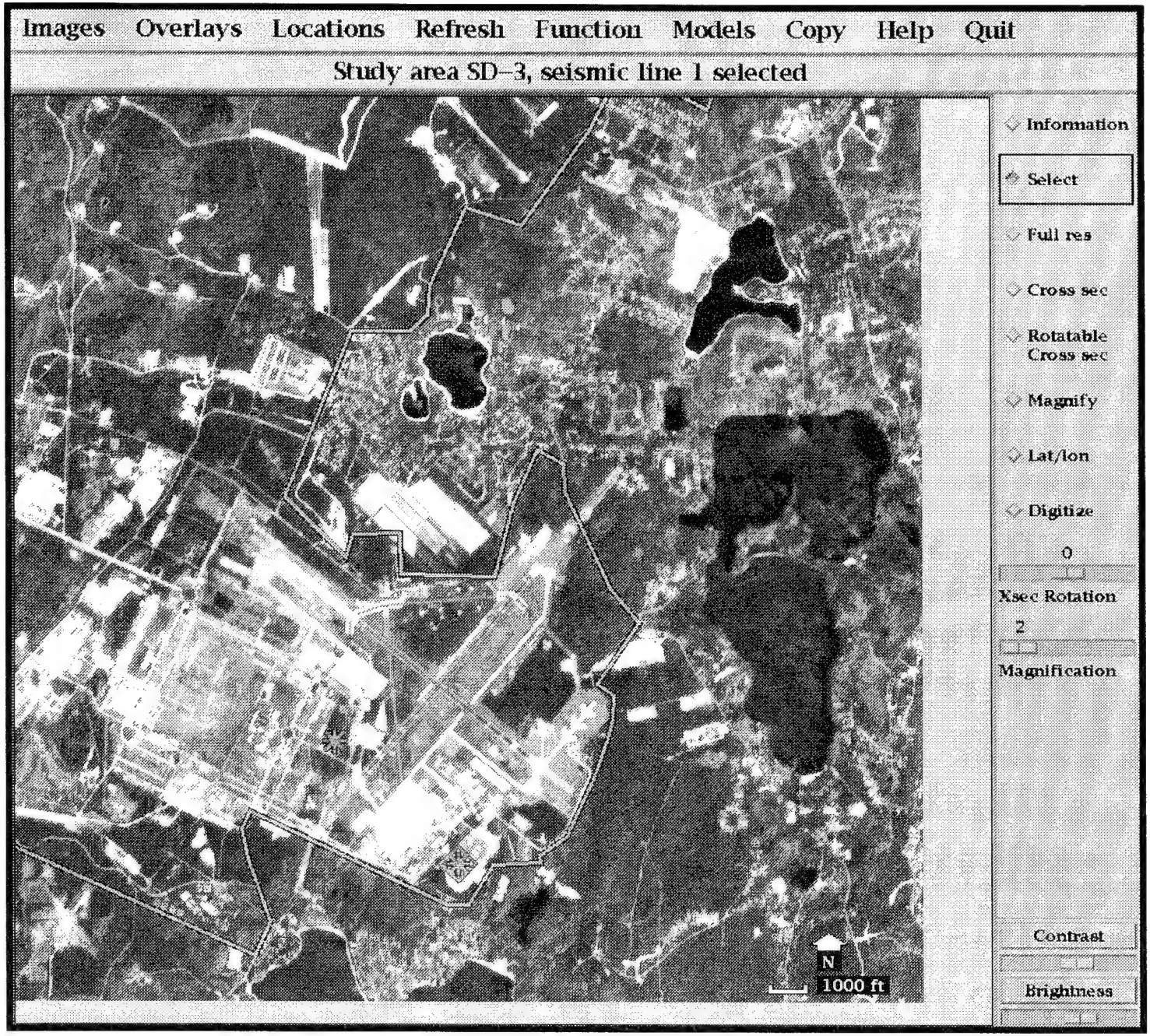

Sample of online geologic well information which can be accessed by clicking on the well location with the mouse. Information regarding the sampling results at any depth can be accessed from this display by selecting the corresponding depth bracket with the mouse.



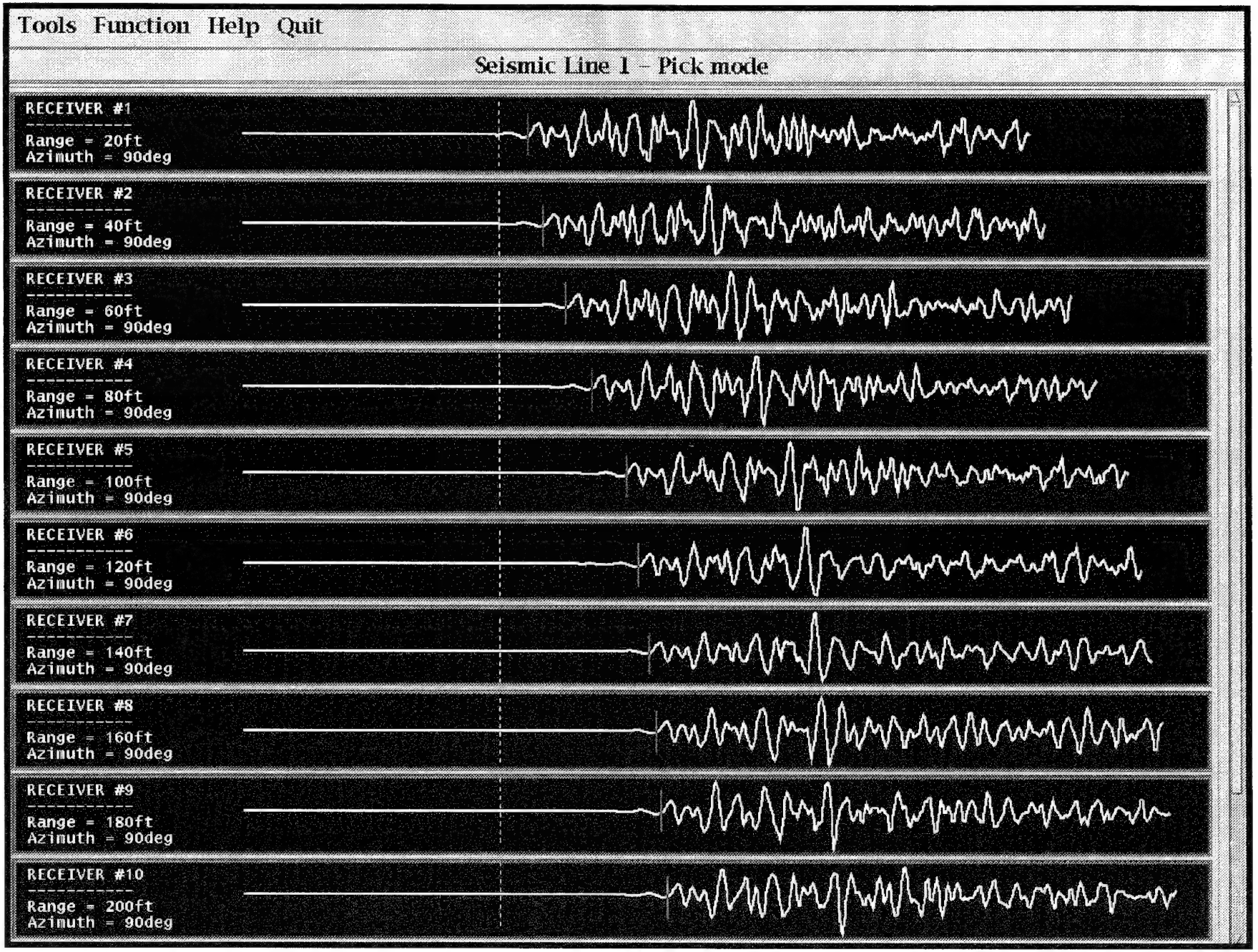

Full resolution SPOT image of the southeast corner of MMR with superimposed MMR boundary and locations of wells, showing an interactively selected line through several hydrologic well locations.



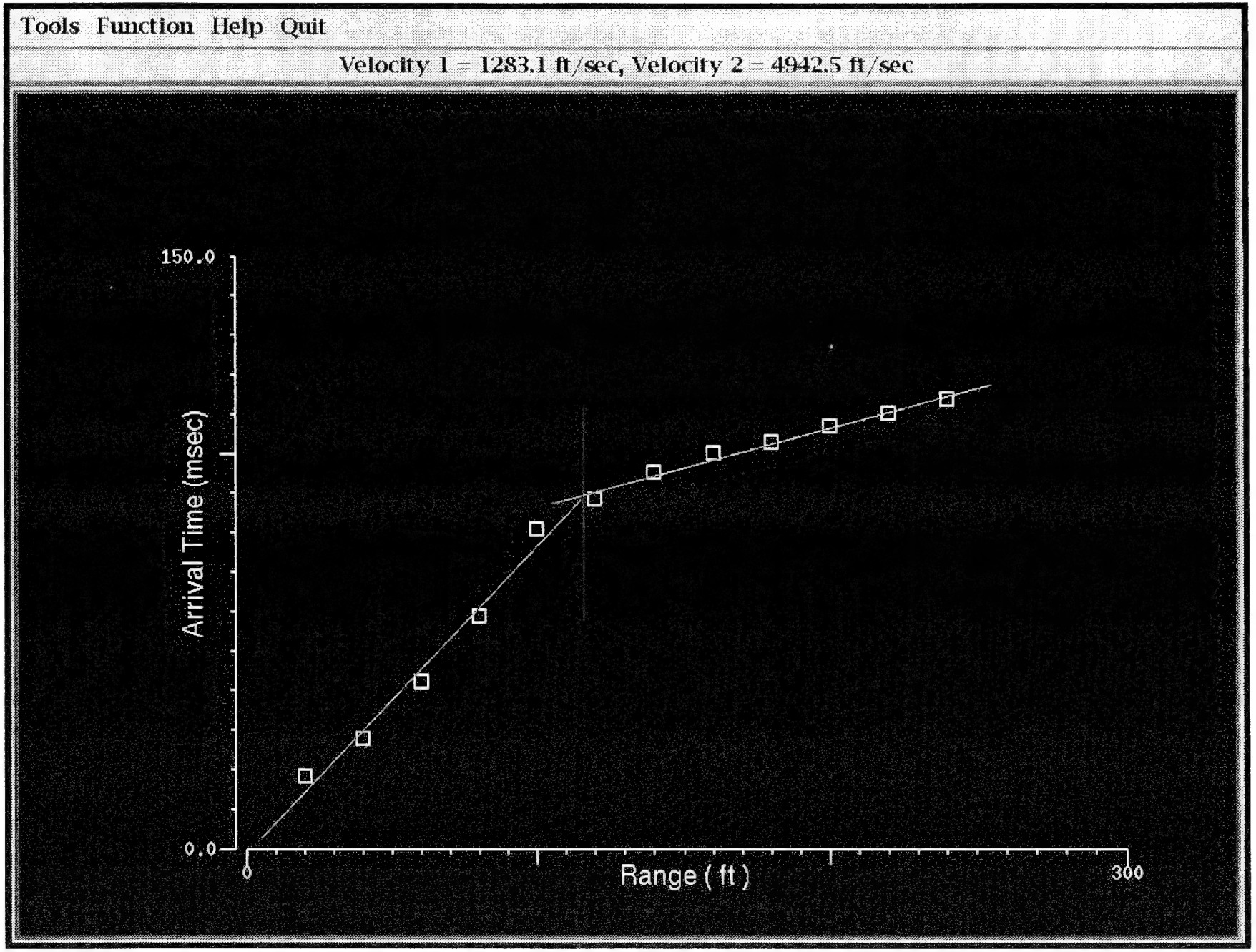

Vertical subsurface section along the interactively selected line from the previous figure showing the variations in topography, depth to water table and depth of penetration of the hydrologic wells encountered along that line.



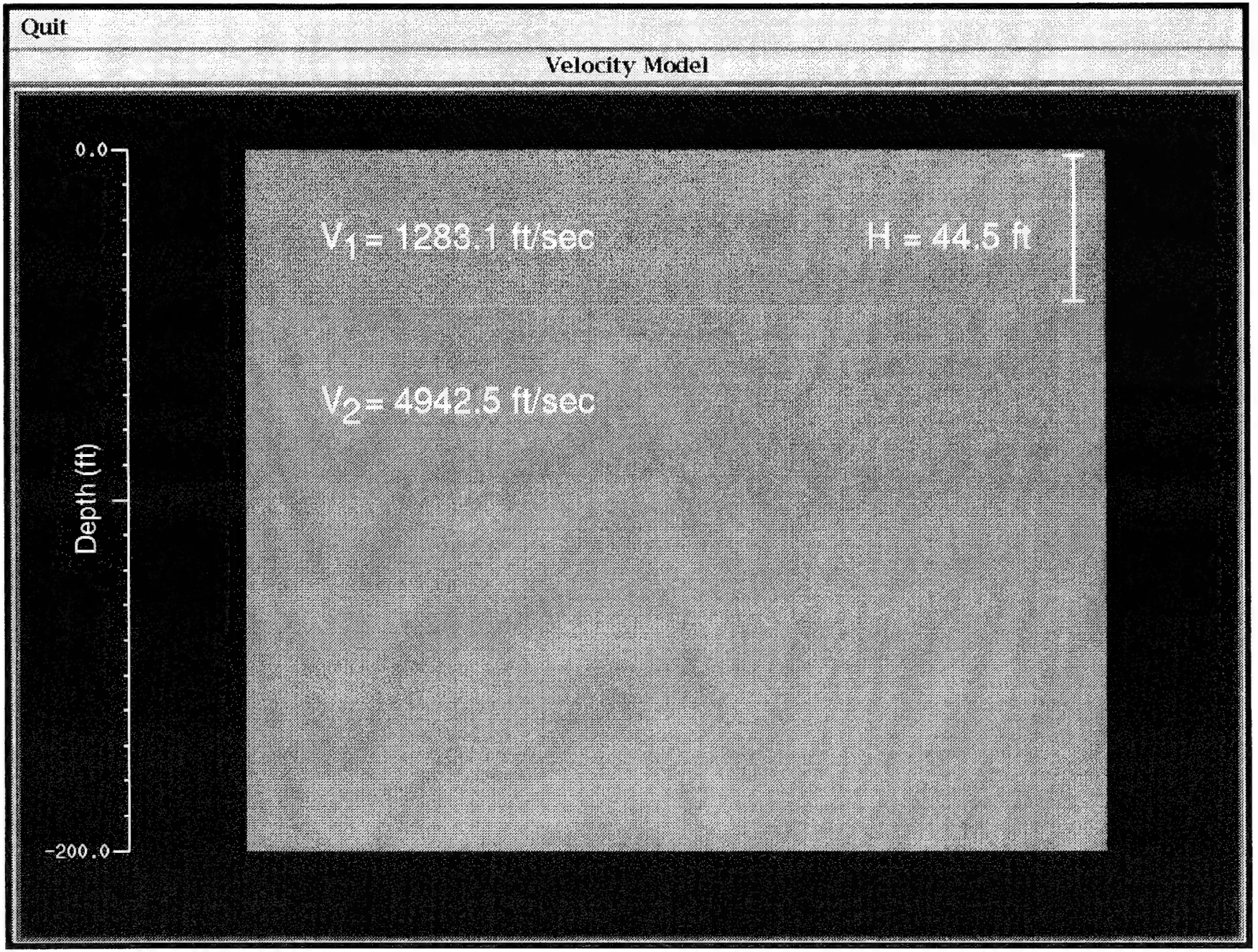

Full resolution SPOT image of the southeast corner of the MMR with superimposed MMR boundary and locations of seismic surveys (asterisks).



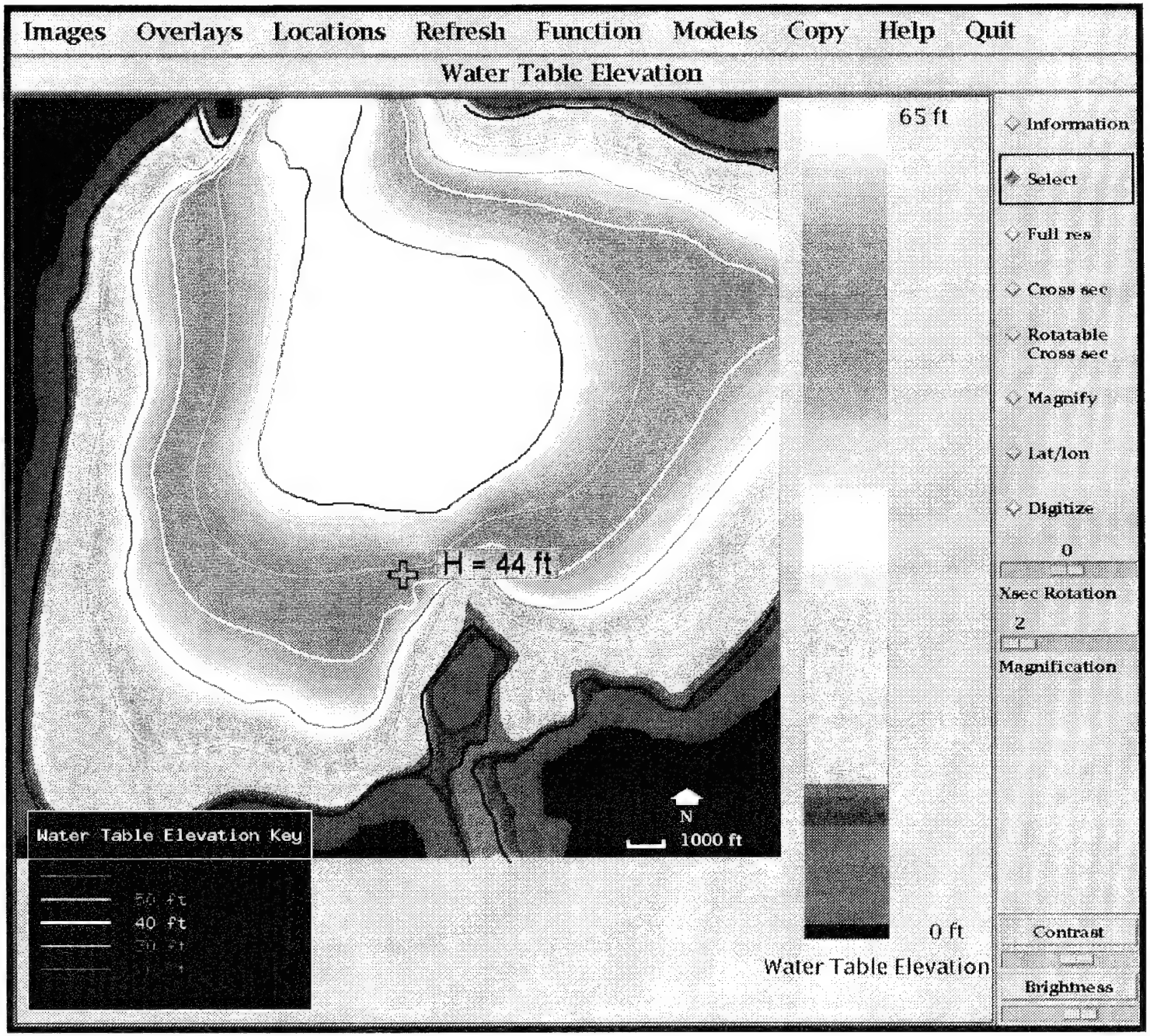

Seismic profile for the selected survey showing the recorded data in order of increasing distance from the source. The dashed vertical line denotes the shot time while the short vertical lines through each trace denote the interactively selected signal onset times.



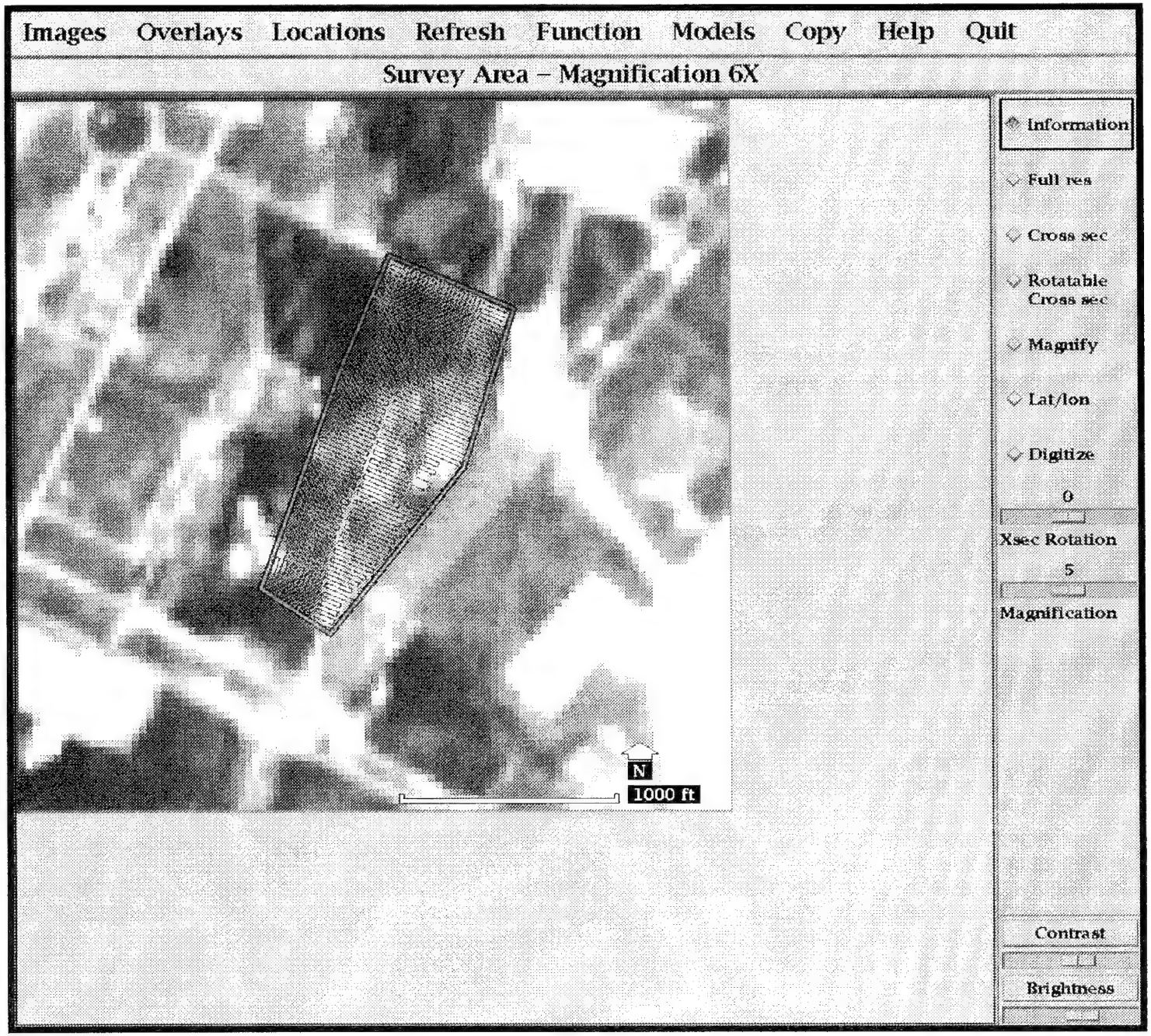

Travel time curve showing the selected seismic first arrival times from the previous figure as a function of distance from the source. The vertical line denotes the interactively selected critical distance separating arrivals with different characteristic velocities.



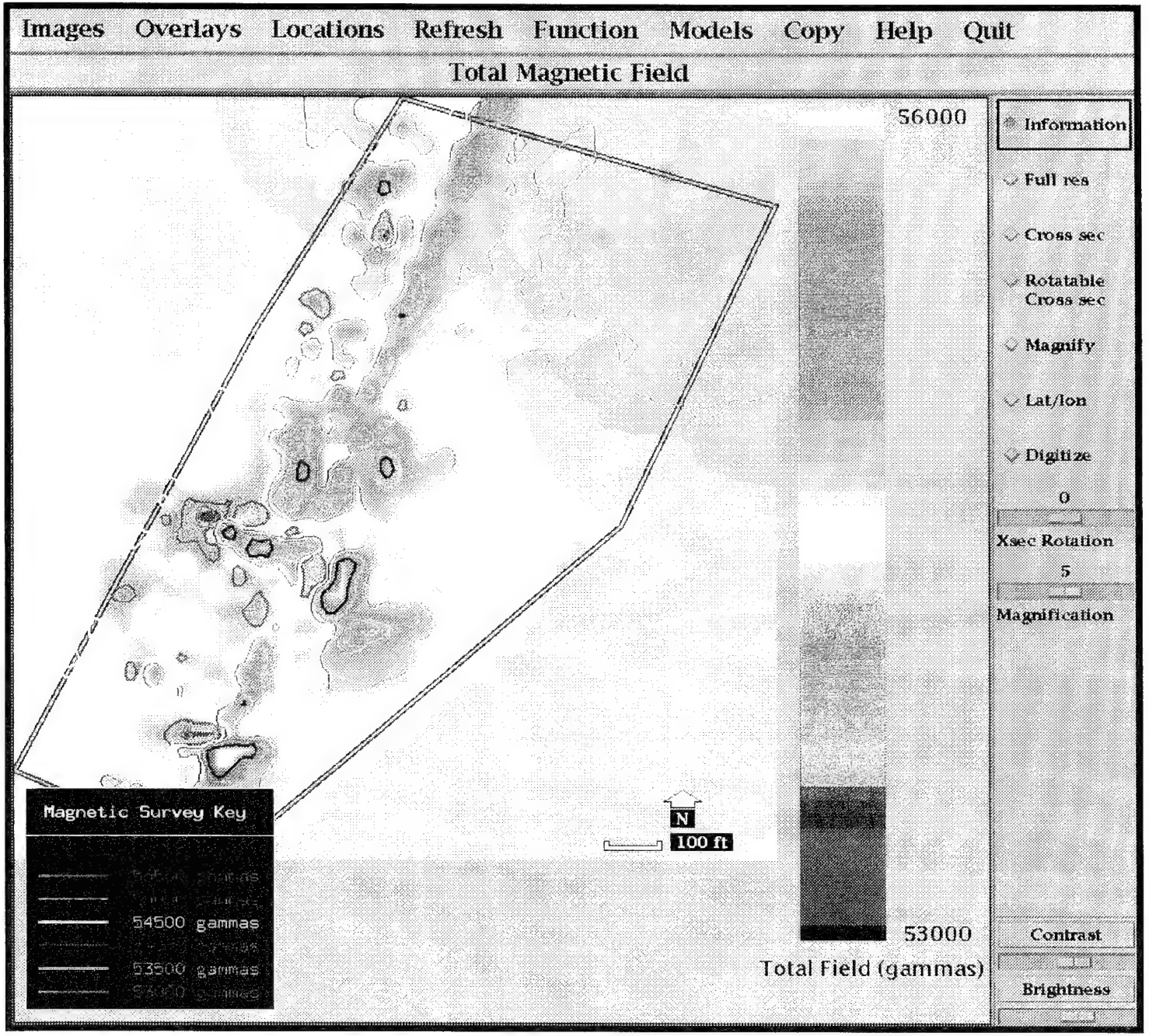

Subsurface vertical velocity model along the selected seismic survey line. This model was automatically determined using the travel time data and critical distance estimate shown on the previous figure.



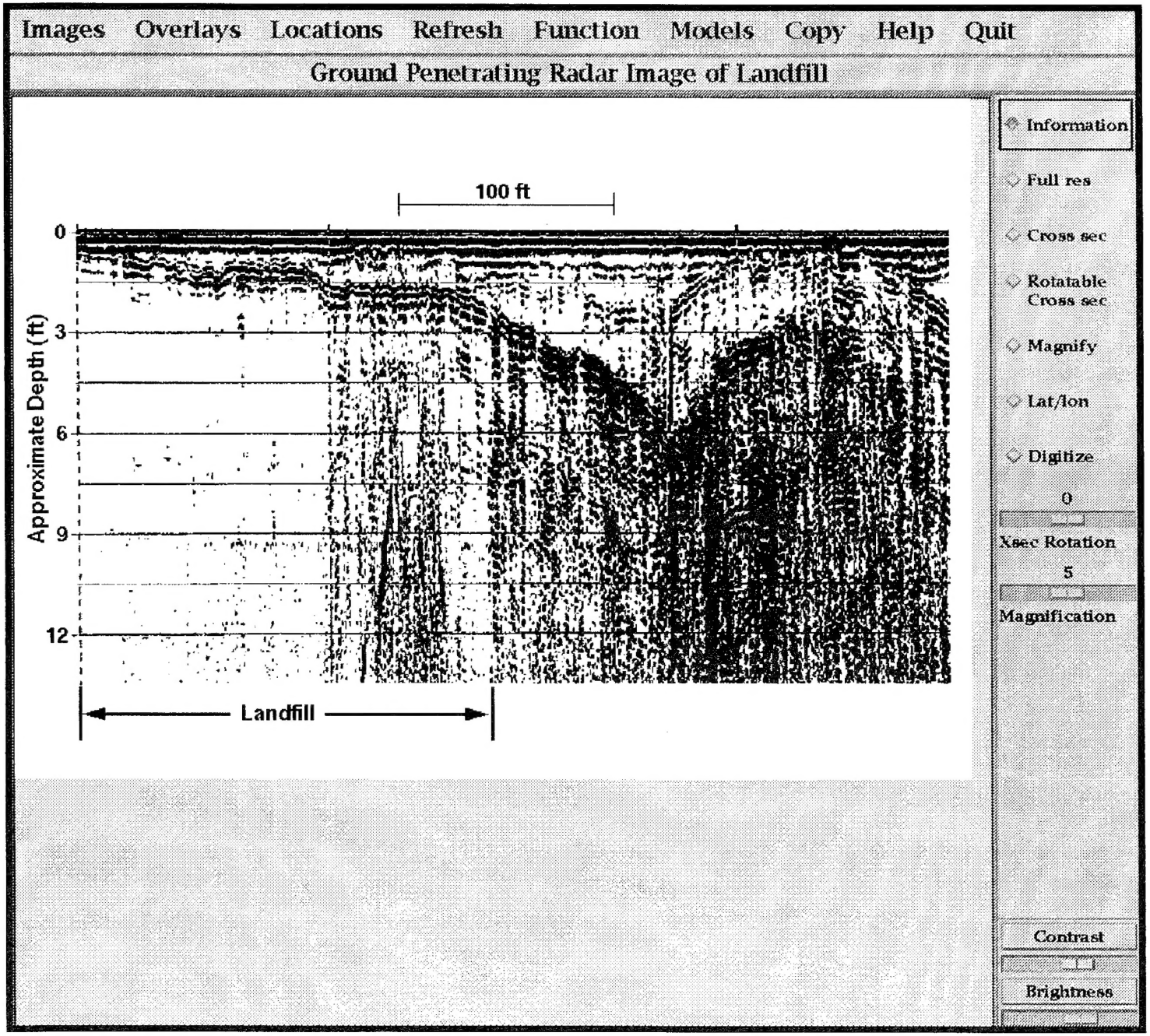

Comparison of the color-coded hydrologic map of depth to water table for Western Cape Cod with the super-imposed water table depth (cross) determined from the seismic survey model shown in the previous figure.



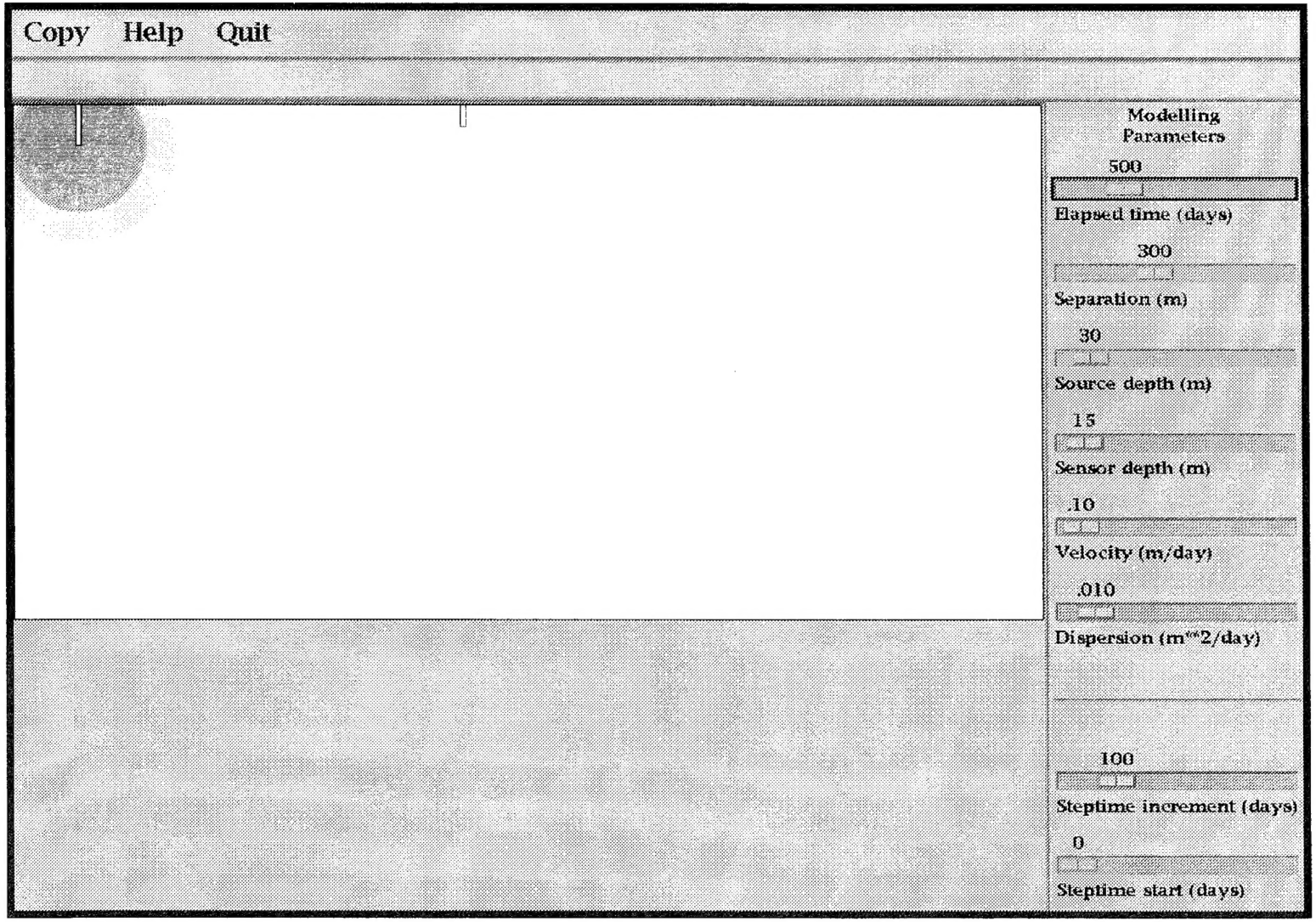

Magnified (X6) full resolution SPOT image of MMR landfill Study Area LF-2, showing locations of magnetic survey lines.



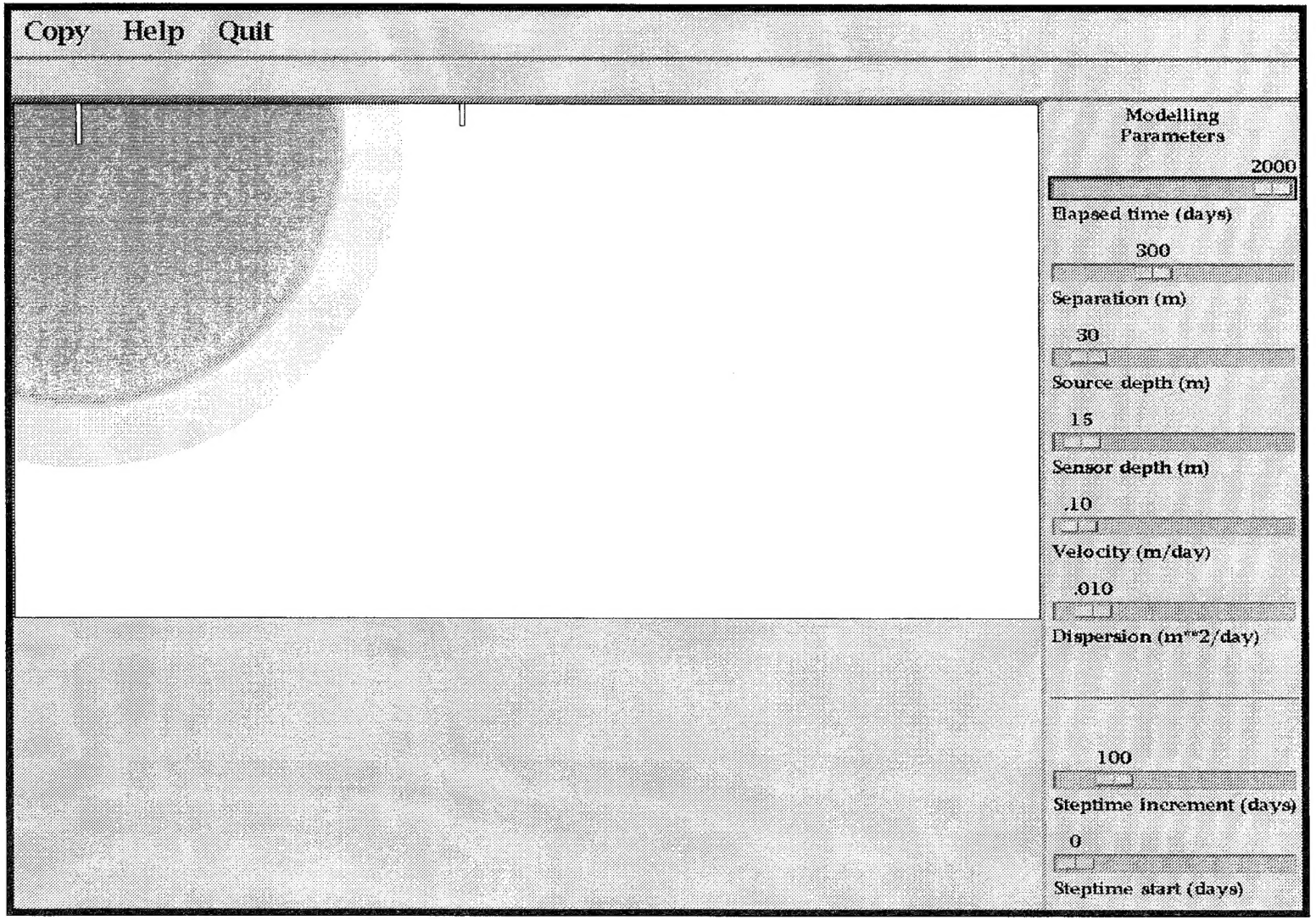

Color-coded contour plot of total magnetic field variation across the LF-2 Study Area shown on the previous figure.




Ground penetrating radar (GPR) profile along a survey line across landfill Study Area LF-2.




Advective-dispersive transport modeling result illustrating the time-dependent growth of a contaminant plume in a homogeneous groundwater system, T = 500 days.




Computed contaminant plume boundary, T = 2000 days.

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